Massachusetts Water Resources Authority

Final Variance Report for Alewife Brook and the Upper Mystic River

EOEA No. 10335

July, 2003

Metcalf & Eddy

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Frederick A. Laskey
Executive Director

July 1, 2003

Mr. Steven G. Lipman, P.E.
Special Projects Coordinator
Massachusetts Department of Environmental Protection
Commissioner's Office
One Winter Street
Boston, MA 02108

RE: Section C. (1) of the MA Department of Environmental Protection's March 5, 1999 Final Variance for CSO Discharges to the Alewife/Upper Mystic Basin and its May 8, 2002 Final Determination on the Extension to the Variance

Dear Mr. Lipman:

In accordance with the Final Variance for CSO Discharges to the Alewife/Upper Mystic Basin issued by the Massachusetts Department of Environmental Protection (DEP) on March 5, 1999, and amended on May 8, 2002, transmitted herewith are two (2) copies of the Final Variance Report for Alewife Brook and the Upper Mystic River dated July, 2003. Two copies of this document have also been delivered this date to the United States Environmental Protection Agency Region I office.

If you have any questions or require additional information on this matter, please contact us.

Sincerely,

Michael J. Hornbrook
Chief Operating Officer
Massachusetts Water Resources Authority

File: 5716.17.8
3000.20
cc: K. Brander, DEP
E. Hall, EPA
M. Wagner, EPA
O. O'Riordan, City of Cambridge
J. Lastovica, City of Somerville

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Executive Summary

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EXECUTIVE SUMMARY

This report presents the results of evaluations conducted in accordance with the Final Variance for CSO Discharges to the Alewife/Upper Mystic Basin issued by the Massachusetts Department of Environmental Protection (DEP) on March 5, 1999, and amended on May 8, 2002. The current water quality classification for the Alewife/Upper Mystic Basin is Class B, which requires elimination of CSO discharges. One of the key issues to be addressed through DEP's review of the information collected under the conditions of the Variance is whether the water quality classification for the Alewife/Upper Mystic Basin should be revised to Class B_{CSO}, if it is shown that elimination of CSOs is infeasible, for reasons listed in federal regulations. B_{CSO} would allow occasional CSO discharges as long as Class B standards could be met at least 95 percent of the time, based on CSO loads only. If DEP determines that Class B_{CSO} is appropriate for the Alewife/Upper Mystic Basin, then the appropriate level of CSO control within the Class B_{CSO} standard must also be determined.

Under Section C(1) of the Variance, as amended on May 8, 2002, the Massachusetts Water Resources Authority (MWRA) was required to prepare a report that must include the following elements:

i. a description of the combined sewer systems in Cambridge and Somerville, and other associated interceptors and sewer system facilities

ii. a reassessment of the recommended CSO abatement plan in the Alewife/Upper Mystic Basin and alternatives representing higher levels of CSO control, up to and including elimination. The reassessment must include: an analysis of the CSO, stormwater, and upstream pollutant loads of the alternatives; predictive modeling to estimate the water quality benefits of the CSO abatement alternatives; measures to be taken to minimize CSOs and mitigate impacts of any CSO discharges which will not be eliminated; and the costs of the alternatives.

iii. a final recommended plan for CSO abatement in the Alewife/Upper Mystic Basin, which shall comply with the state and federal CSO policies

iv. a description of the financial impact of the recommended CSO abatement plan, developed pursuant to EPA Guidance

This report addresses each of the elements required under Section C.(1) of the Variance. The recommended CSO control plan presented for the Alewife/Upper Mystic Basin represents a modification to the plan originally presented in the MWRA's 1994 System Master Plan and CSO Conceptual Plan, based on changed conditions encountered during the initial implementation phases of the original plan. The changes to the 1994 plan were first presented in the April 30, 2001 *Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook*, and certain elements of the plan were described in more detail in the May, 2003 *Response to Comments on the Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook.*

Chapter 1 of this report provides an overview of the requirements for the Final Variance Report, followed by a brief description of the recommended plan and a summary of the analyses conducted in support of the recommended plan.

Chapter 2 of this report presents a summary of the regulatory process that led to the requirement for development of this report, and the regulatory process that will ensue following submittal of the report. It also provides background on the MWRA's long term CSO control planning process.

Chapter 3 presents a summary description of the wastewater collection systems in Cambridge and Somerville, as well as the MWRA transport system associated with the Alewife Brook area. A description of the collection system model used to develop and evaluate the CSO control alternatives is also presented. A key element of this chapter is the description of the changed conditions that were encountered in the city of Cambridge combined sewer system that prompted the need for a reassessment of the CSO control plan. Activities to update and re-calibrate the MWRA's collection system model to incorporate the changed conditions are also described.

Chapter 4 presents a summary of water quality sampling data collected in accordance with the conditions of the variance, followed by a description of the receiving water

model used to simulate water quality conditions in Alewife Brook and the Upper Mystic River. Key findings in this chapter include the following:

- Under existing conditions, the Class B criteria for fecal coliform bacteria are generally not met in Alewife Brook and parts of the Upper Mystic River during dry weather. This finding was supported by sampling data, which were used to recalibrate the receiving water model.

- The average concentration of fecal coliform bacteria in stormwater tributary to Alewife Brook and the Upper Mystic River was found to be approximately 16,200 counts/100ml, based on recent sampling data. This is approximately half the concentration assumed during earlier CSO planning work conducted by MWRA.

- During wet weather, the receiving water model predicted that fecal coliform densities in Alewife Brook can be on the order of 10,000 counts/100ml based on non-CSO sources only (i.e. assuming elimination of CSO discharges).

Chapter 5 presents the methodology used in developing and evaluating CSO control alternatives for Alewife Brook; presents the baseline conditions (system hydraulics and work completed to date) from which the CSO control alternatives were developed; provides descriptions of the alternatives that were developed; and summarizes the hydraulic performance for the range of alternatives. A key finding in this chapter was that closing the outfalls following complete sewer separation would worsen system backup and flooding in the upstream collection system and would worsen flooding in the Alewife Brook as compared with existing conditions in the 25-year storm.

Chapter 6 presents a comparison of the CSO control alternatives for Alewife Brook that were developed and described in Chapter Five. The alternatives are compared on the basis of cost per unit of pollutant load removed, cost/performance curves, water quality impacts, and non-monetary factors. The affordability of alternatives is also presented. Key findings in this chapter include the following:

- Targeted Sewer Separation Alternative A (described below) was found to be the most cost-effective alternative in terms of cost per pollutant load removed. To achieve marginally higher levels of pollutant removal would require significant increase in cost.

- Receiving water modeling of Targeted Sewer Separation Alternative A indicated that providing higher levels of CSO control at greater cost would provide very little benefit in terms of reduction of the magnitude or duration of wet weather impacts to Alewife Brook or the Upper Mystic River, and would have no impact on the magnitude or duration of the extensive non-CSO impacts to the receiving waters.

- Under Targeted Sewer Separation Alternative A, Class B criteria would be met 98.5 percent of the time in Alewife Brook based on CSO loads only. Non-compliance would be associated with the largest storms that occur during an average rainfall year, with contributions of pollution from non-CSO sources predominating.

- Based on the affordability analysis, increasing the cost of the CSO control plan for Alewife Brook beyond the current cost for Targeted Sewer Separation Alternative A would result in substantial and widespread social and economic impact in the city of Chelsea, and could potentially result in substantial and widespread social and economic impact in the cities of Boston and Cambridge.

- Based on these findings, Targeted Sewer Separation Alternative A is selected as the recommended CSO control plan for Alewife Brook.

Chapter 7 summarizes the components of the recommended plan for CSO control for Alewife Brook, followed by a discussion of the incremental benefits of phased implementation of the plan. This chapter concludes with a discussion of why full sewer separation for Alewife Brook CSOs is not recommended, in part because it would not allow CSO elimination. The recommended plan, Targeted Sewer Separation Alternative A, is described below.

RECOMMENDED PLAN

The revised recommended plan, Targeted Sewer Separation Alternative A, includes the following elements:

- Complete separation of the combined sewer system upstream of regulator RE-041 (outfall CAM004), and closure of the regulator. The scope of this work also includes construction of a new stormwater outfall for the CAM004 tributary area, a stormwater wetland/detention area downstream of the new outfall to attenuate flows, and sewer flushing/grit accumulation chambers to control the buildup of sediment in the new pipes.

- Separation of the combined manholes upstream of outfall CAM400 and closure of the outfall as a CSO, with the existing outfall to remain as a separate drainage outfall. (Closure of the CAM400 CSO outfall is an additional measure not included in the previous NPC/RTC plan.)

- Increasing the capacity of the dry weather flow connections between the CSO regulator and the MWRA interceptor for outfalls CAM002, CAM401B and SOM01A

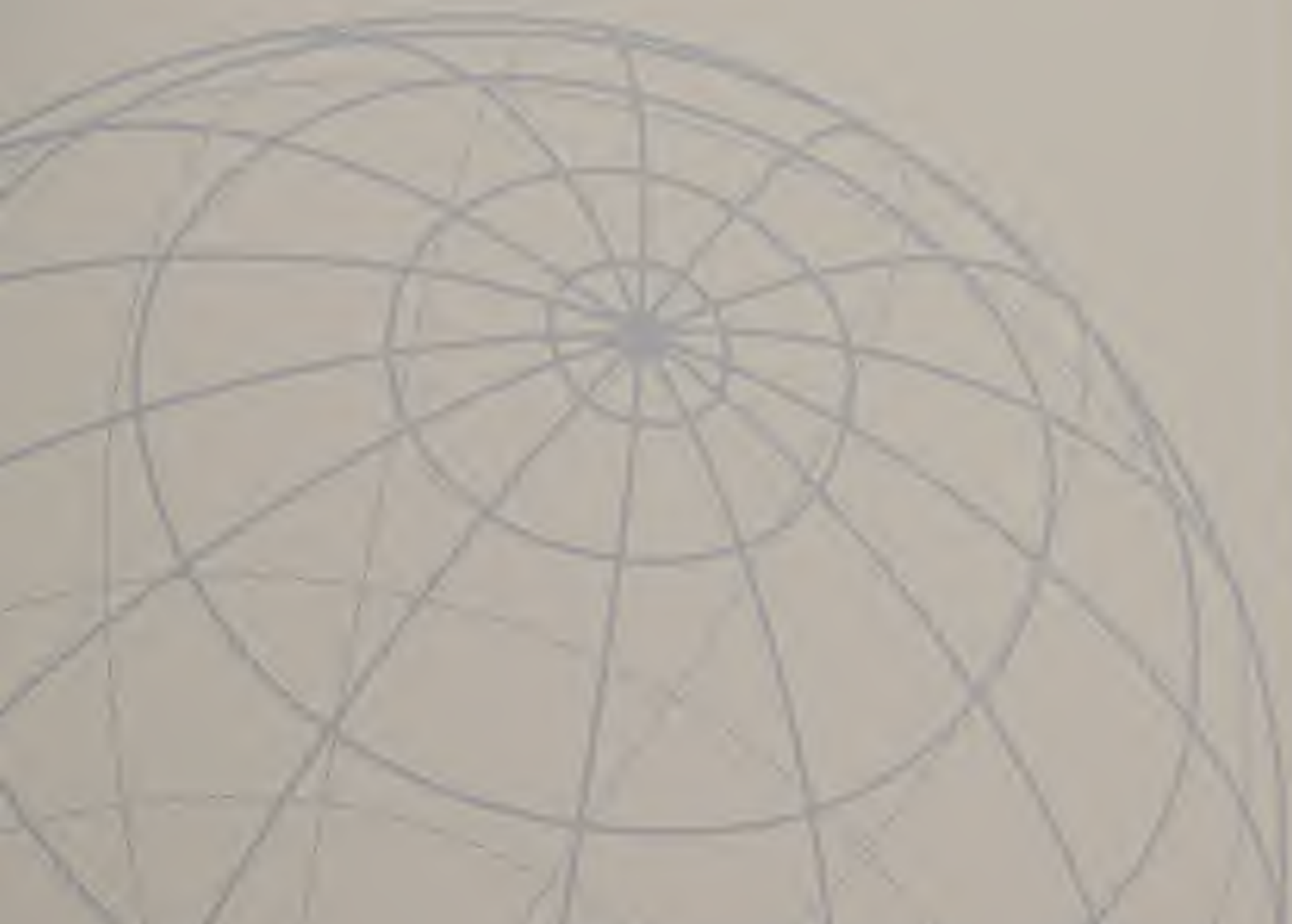
- Providing relief of the siphon between the Alewife Brook Branch Sewer and the Alewife Brook Conduit downstream of the Rindge Avenue combined sewer

- Providing a hydraulic relief gate at outfall MWR003, to relieve the hydraulic grade line during extreme storm events

- Providing floatables control for outfalls CAM001, CAM002, MWR003, CAM401A, CAM401B and SOM01A

The total estimated capital cost of the recommended plan is $73.7 million (Engineering News Record Boston-area Construction Cost Index 7177). Upon completion of the plan, the average annual activation frequency of CSO discharge to Alewife Brook will be reduced from 63 to 7, and the average total annual volume of CSO will be reduced from 50 to 7.3 million gallons.

With the recommended plan in place, CSOs will not preclude attainment of Class B water quality criteria 98.5 percent of the time on average. However, data collected by MWRA and others demonstrated that in dry weather, when CSOs are not active, the Class B criteria for fecal coliform bacteria are generally not attained in Alewife Brook. Based on the affordability assessment conducted in accordance with EPA guidelines, increasing the cost of the CSO control plan for the Alewife/Upper Mystic basin above the cost of the recommended plan would result in substantial and widespread social and economic impact in the city of Chelsea, and could potentially result in substantial and widespread social and economic impact in the cities of Boston and Cambridge, with negligible improvement to the water quality of Alewife Brook. The analyses presented herein therefore support the recommendation to implement Targeted Sewer Separation Alternative A, and the revision of the water quality standard for Alewife Brook and the Upper Mystic River to Class B_{CSO}.



Section One

CHAPTER ONE
INTRODUCTION

This report presents the results of evaluations conducted in accordance with the Final Variance for CSO Discharges to the Alewife/Upper Mystic Basin issued by the Massachusetts Department of Environmental Protection (DEP) on March 5, 1999, and amended on May 8, 2002. The intent of the Variance was to

> ...provide additional time ... to investigate sources of discharges and to conduct analyses to determine the potential for additional water quality improvements from higher levels of CSO treatment or remediation of stormwater discharges to the Alewife/Upper Mystic Basin. (DEP *Final Variance for CSO Discharges to the Alewife/Upper Mystic Basin*, March 5, 1999)

The current water quality classification for the Alewife/Upper Mystic Basin is Class B, which requires elimination of CSO discharges. One of the key issues to be addressed through DEP's review of the information collected under the conditions of the Variance is whether the water quality classification for the Alewife/Upper Mystic Basin should be revised to Class B_{CSO}, which would allow occasional CSO discharges as long as Class B standards could be met at least 95 percent of the time, based on CSO loads, only. If DEP determines that Class B_{CSO} is appropriate for the Alewife/Upper Mystic Basin, then the appropriate level of CSO control within the Class B_{CSO} standard must also be determined.

Under Section C(1) of the Variance, as amended on May 8, 2002, the Massachusetts Water Resources Authority (MWRA) was required to prepare a report that must include the following elements:

i. a description of the combined sewer systems in Cambridge and Somerville, and other associated interceptors and sewer system facilities

ii. a reassessment of the recommended CSO abatement plan in the Alewife/Upper Mystic Basin and alternatives representing higher levels of CSO control, up to and including elimination. The reassessment must

include: an analysis of the CSO, stormwater, and upstream pollutant loads of the alternatives; predictive modeling to estimate the water quality benefits of the CSO abatement alternatives; measures to be taken to minimize CSOs and mitigate impacts of any CSO discharges which will not be eliminated; and the costs of the alternatives.

iii. a final recommended plan for CSO abatement in the Alewife/Upper Mystic Basin, which shall comply with the state and federal CSO policies

iv. a description of the financial impact of the recommended CSO abatement plan, developed pursuant to EPA Guidance

The information presented herein addresses each of the elements required under Section C(1) of the Variance. The recommended CSO control plan presented for Alewife/Upper Mystic Basin represents a modification to the plan originally presented in the MWRA's 1994 System Master Plan and CSO Conceptual Plan, based on changed conditions encountered during the initial implementation phases of the original plan. The changes to the 1994 plan were also presented in the April 30, 2001 *Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook*, and certain elements of the plan were described in more detail in the May, 2003 *Response to Comments on the Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook.*

RECOMMENDED PLAN

The revised recommended plan includes the following elements:

- Complete separation of the combined sewer system upstream of regulator RE-041 (outfall CAM004), and closure of the regulator. The scope of this work also includes construction of a new stormwater outfall for the CAM004 tributary area, a stormwater wetland/detention area downstream of the new outfall to attenuate flows, and sewer flushing/grit accumulation chambers to control the buildup of sediment in the new pipes.
- Separation of the combined manholes upstream of outfall CAM400 and closure of the outfall as a CSO (the existing outfall will remain as a separate drainage outfall).
- Increasing the capacity of the dry weather flow connections between the CSO regulator and the MWRA interceptor for outfalls CAM002, CAM401B and SOM01A

- Providing relief of the siphon between the Alewife Brook Branch Sewer and the Alewife Brook Conduit downstream of the Rindge Avenue combined sewer
- Providing a hydraulic relief gate at outfall MWR003, to relieve the hydraulic grade line during extreme storm events
- Providing floatables control for outfalls CAM001, CAM002, MWR003, CAM401A, CAM401B and SOM01A

The total estimated capital cost of the recommended plan is $73.7 million (Engineering News Record Boston-area Construction Cost Index 7177). Upon completion of the plan, the average annual activation frequency of CSO discharge to Alewife Brook will be reduced from 63 to 7, and the average total annual volume of CSO will be reduced from 50 to 7.3 million gallons.

With the recommended plan in place, CSOs will not preclude attainment of Class B water quality criteria approximately 98 percent of the time on average. However, data collected by MWRA and others demonstrated that in dry weather, when CSOs are not active, the Class B criteria for fecal coliform bacteria are generally not attained in Alewife Brook. Based on the affordability assessment conducted in accordance with EPA guidelines, increasing the cost of the CSO control plan for the Alewife/Upper Mystic basin above the cost of the recommended plan would result in substantial and widespread social and economic impact in the city of Chelsea, and could potentially result in substantial and widespread social and economic impact in the cities of Boston and Cambridge. The analyses presented herein therefore support the revision of the water quality standard for Alewife Brook and the Upper Mystic River to Class B_{CSO}.

Prior to development of the recommended plan, field inspections and flow monitoring were conducted to update the characterization of the combined sewer systems in Cambridge and Somerville. These field investigations in turn supported the recalibration of the MWRA's Stormwater Management Model (SWMM) of the collection and transport systems serving the Alewife/Upper Mystic Basin. In parallel with this work, a water quality sampling program was implemented to characterize the quality of CSO and stormwater entering Alewife Brook and the Upper Mystic River, as well as to establish

water quality conditions within the waterways during both dry and wet weather. With this information, the MWRA's receiving water model of Alewife Brook and the Upper Mystic River was updated, and then used to assess baseline conditions and the water quality impacts of the recommended plan.

A range of CSO control alternatives for Alewife Brook was identified and evaluated using both the technology-based and water quality-based approaches. The technology-based approach demonstrated that the recommended plan is the most cost-effective alternative for controlling fecal coliform bacteria, total suspended solids, and biochemical oxygen demand loads from CSO to Alewife Brook. The water quality-based approach demonstrated that providing a higher level of CSO control would not result in significant reductions in the magnitude or duration of wet weather impacts to Alewife Brook and the Upper MysticRiver, due to the predominant influence of non-CSO wet weather sources.

REPORT ORGANIZATION

This report is organized into the following chapters.

Chapter One – Introduction. This chapter provides an overview of the requirements for the Final Variance Report, followed by a brief description of the recommended plan and a summary of the analyses conducted in support of the recommended plan.

Chapter Two – Background. This chapter presents a summary of the regulatory process that has preceded development of this report, and the subsequent regulatory process that will ensue following submittal of the report. It also provides background on the MWRA's long term CSO control planning process.

Chapter Three - Description And Update Of Baseline Collection System Conditions. This chapter presents a summary description of the wastewater collection systems in Cambridge and Somerville, and the MWRA transport system associated with the Alewife

Brook area. Following the system description, a description of the collection system model used to develop and evaluate the CSO control alternatives is presented.

Chapter Four - Update Of Baseline Water Quality Conditions. This chapter presents a summary of water quality sampling data collected in accordance with the conditions of the variance, followed by a description of the receiving water model used to simulate water quality conditions in Alewife Brook and the Upper Mystic River. Refinements to the calibration of the receiving water model based on recent sampling data are presented, along with the results of simulations of baseline water quality conditions.

Chapter Five - Development Of CSO Control Alternatives. This chapter presents the methodology used in developing and evaluating CSO control alternatives for Alewife Brook; presents the baseline conditions from which the CSO control alternatives were developed; provides descriptions of the alternatives that were developed; and summarizes the performance of the range of alternatives.

Chapter Six - Evaluation Of CSO Control Alternatives. This chapter presents a comparison of the CSO control alternatives for Alewife Brook that were developed and described in Chapter Five. The alternatives are compared on the basis of cost per unit of pollutant load removed, cost/performance curves, water quality impacts, affordability and non-monetary factors.

Chapter Seven - Recommended Plan. This chapter summarizes the components of the recommended plan for CSO control for Alewife Brook, followed by a discussion of the incremental benefits of phased implementation of the recommended plan. This chapter concludes with a discussion of why elimination of CSOs to Alewife Brook through sewer separation is not recommended.

Section Two

CHAPTER TWO
BACKGROUND

This chapter presents a summary of the regulatory process that has preceded development of this report, and the subsequent regulatory process that will ensue following submission of the report. It also provides background on the MWRA's long term CSO control planning process.

REGULATORY CONTEXT OF THIS FINAL VARIANCE REPORT

In its December 31, 1997 Administrative Determination of Certain CSO Impacted Waters, the Massachusetts Department of Environmental Protection (DEP) granted a short-term Variance under its Surface Water Quality Standards for the Alewife/Upper Mystic Basin. This Variance was a short-term modification to the water quality standards, during which time MWRA and other government agencies would investigate the potential for achieving water quality improvements to the basin through higher levels of CSO control or through remediation of stormwater.

On March 5, 1999, DEP formally issued the three-year Variance, to remain in effect until March 5, 2002. That Variance was later extended by 18 months, and will now conclude on September 5, 2003 (refer to Appendix A for a copy of the original 1999 Variance and the 2002 extension). The original Variance issued on March 5, 1999 required MWRA to file a report with DEP presenting the information collected during the Variance period, including the following:

1. updated information on the combined sewer systems in Cambridge and Somerville, regarding how the actual condition of the systems varies from what was modeled in the 1997 Final CSO Facilities Plan

2. a reassessment of the recommended CSO abatement plan and alternatives representing higher levels of CSO control (including analysis of CSO, stormwater and upstream pollutant loads; model estimated water quality impacts; and costs)

3. a final recommended plan for CSO abatement

This Final Variance Report has been prepared to meet those objectives, to present the data gathered over the past 40 months and to present the recommended plan, along with supporting information related to technical issues, cost, and affordability.

REVIEW OF THE PLANNING AND REGULATORY PROCESS

The steps involved in the regulatory and planning process for CSO control for Alewife Brook since 1994 are shown on Figure 2-1. As that figure illustrates, there are two separate regulatory tracks along which this project has been proceeding.

The first regulatory track, shown on the left side of the figure, involves those steps related to Massachusetts DEP approval of the project. DEP approvals are primarily related to water quality standards, and to the proposed CSO control alternatives (including technical assessment, cost, and affordability). The second regulatory track, represented on the right side of the figure, concerns Massachusetts Environmental Policy Act (MEPA) Unit review of the plan, and the kinds of issues that would be addressed in an environmental impact report, such as impact on wetlands, on local traffic, etc. Both processes have been proceeding in parallel, and the requirements of both must be satisfied before a proposed project can be implemented.

Each of the steps in the regulatory and planning process is described below, grouped together into the following three categories:

- **Initial Planning Efforts**, approximately 1994-1999 (Box Nos. 1-6 in Figure 2-1)
- **DEP Regulatory Process**, primarily related to CSO alternatives and water quality standards, 1999-2003 (Box Nos. 7D-9D in Figure 2-1)
- **MEPA Review Regulatory Process**, primarily related to environmental impacts of project related activities, 2001-2003 (Box Nos. 7M -10M in Figure 2-1)

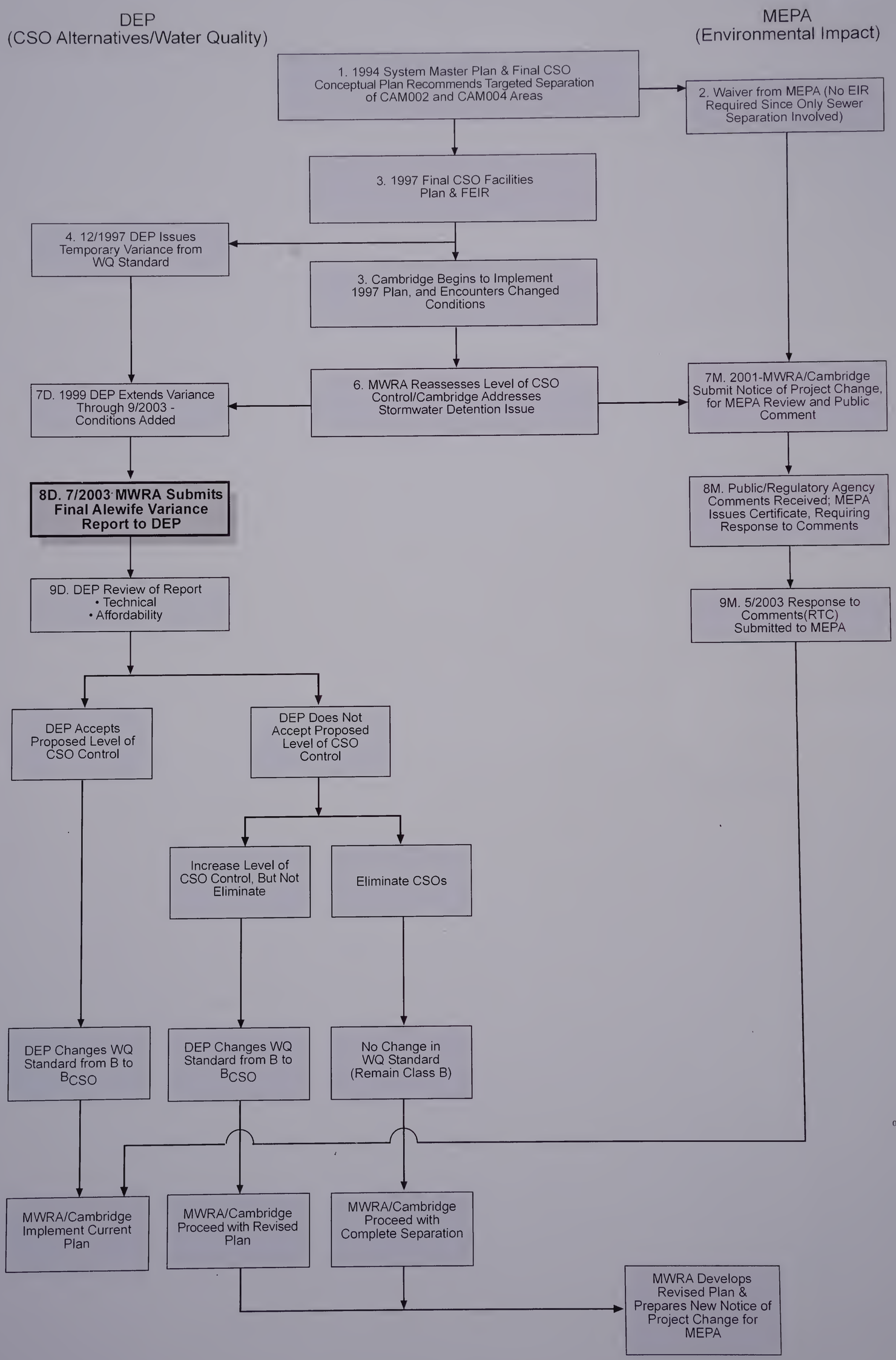


Figure 2-1. Overview of Regulatory Process for Implementation of CSO Control Plan for Alewife Brook

Initial Planning Efforts

1. **1994 Master Plan and CSO Conceptual Plan.** In December 1994, the MWRA completed its CSO Conceptual Plan and System Master Plan (SMP) in accordance with Schedule Six of the Federal Court Order in the Boston Harbor Case. The SMP identified sewer separation upstream of outfalls CAM002 and CAM004 in Cambridge as part of its recommended long term CSO control plan (LTCP) for Alewife Brook. As described in the SMP, this alternative (which also included separation of common manholes upstream of outfall SOM001 in Somerville) was predicted to eliminate CSO discharges from a 3-month, 24-hour storm. On an annual basis, overflows were predicted to be controlled to four or less in the typical year. This alternative was the least-cost alternative to provide control of the 3-month storm. It was noted that this alternative was also consistent with the intent of the city of Somerville to eventually eliminate CSOs into the Tannery Brook Drain (outfall SOM01A), and would also return natural drainage to Alewife Brook.

   While receiving water modeling was not conducted for Alewife Brook as part of the development of the SMP, the relative loadings to the brook from CSO and separate stormwater were established. In the 3-month storm, CSO contributed approximately one quarter of the total fecal coliform bacteria load to Alewife Brook, and in the 1-year storm, CSO contributed over half of the total load. For total suspended solids (TSS) and five-day biochemical oxygen demand (BOD), the contributions from CSO on an annual basis were minimal as compared with the contributions from stormwater. From these loading data, it was inferred that stormwater would continue to contribute to non-attainment of water quality standards even if CSO were totally eliminated.

   The recommendation to provide targeted sewer separation along Alewife Brook was presented as a cost-effective means to provide a reasonable level of CSO control, where stormwater impacts would negate the potential benefits of higher (and more costly) levels of CSO control.

2. **Waiver from MEPA.** As the MWRA's CSO control program moved into facilities planning, certain projects were determined not to require formal environmental impact reports, and were granted Phase I waivers. The elements of the overall LTCP recommended plan that involved sewer separation projects, including the Alewife Brook CSO plan for separation of outfalls CAM002 and CAM004, received a Phase I Waiver from further environmental review, in 1995. This MEPA decision was based on their determination that

> "...much of the work for sewer separation will take place under streets, [and] it will have little, if any, potential to cause significant short term (construction) or long term impacts on the environment. In addition, more immediate water quality benefits will be realized through early implementation of selected projects." (MEPA *Final Record of Decision*, July 14, 1995)

3. **1997 Final CSO Facilities Plan and EIR (FEIR).** The CAM002 and CAM004 sewer separation projects in Cambridge were developed to a higher level of detail early in the facilities planning process, and the results of the additional development were presented in a December 1996 *Draft Technical Memorandum on Pre-Design Planning for Sewer Separation Projects*. For the CAM002 and CAM004 projects, the further development involved a street-by-street assessment of the scope of separation work expected to be required. This assessment was based on reviewing existing sewer mapping and design drawings. Field verification of conditions was not included in the scope of the study. The estimated cost for the projects was updated by establishing average unit costs for sewer separation from recent sewer separation jobs in other parts of Cambridge, and applying the unit costs to the lengths of streets to be separated from the street-by-street assessment.

In August 1997, MWRA released the FEIR, which recommended a long-term plan for controlling CSOs in the metropolitan Boston area. The recommended plan was the outcome of several years of wastewater management planning, environmental review and public input, which MWRA began in 1992. Building on the 1994 Final CSO Conceptual Plan and System Master Plan, the 1997 plan proposed 25 distinct projects in the communities where CSOs exist - Boston, Cambridge, Chelsea, and Somerville. Each of the recommended projects responded to:

1) the site-specific sewer system conditions that contribute to localized CSO discharges;

2) a demonstrated site-specific potential for water quality improvement; and

3) site-specific receiving water use goals.

In accordance with the new National CSO Policy, issued by EPA in April, 1994, MWRA had developed the long-term CSO control plan through a series of evaluations that included:

- characterization of the sewer system and system performance in wet weather;
- detailed, technology-based review of CSO control alternatives covering a full range of control levels and costs; and
- water quality-based evaluations of the potential for water quality improvement, including attainment of use standards, that took into account both CSO and non-CSO sources of pollution.

The resulting plan proposed site-specific projects intended to reduce CSO discharges and impacts to the greatest extent feasible at reasonable cost. Reasonable cost was determined through affordability reviews, cost-benefit analyses and public input on the allocation of public funds, which prioritized receiving waters and uses. The 1997 recommended plan proposed spending a total of $440 million (1997 dollars) to eliminate CSO discharges to sensitive use areas (i.e. beaches and shellfish beds), minimize or treat (but not eliminate) CSO discharges to less-sensitive receiving waters, and provide a means to control floatable materials at remaining CSO outfalls. MWRA estimated that the plan would result in an 88 percent reduction in system-wide annual CSO volume from 1988 conditions, with 95 percent of the remaining overflow receiving detention/treatment or screening and disinfection at five CSO treatment facilities. The reduction in CSO discharges would allow attainment of Class B ("fishable/swimmable") water quality standards at least 95 percent of the time. Like all of the other MWRA wastewater system improvement programs, the CSO plan would be paid for by all ratepayers in the MWRA sewer district, which comprises 43 communities. The plan received state and federal regulatory review and approvals in late 1997 and early 1998.

To meet the requirements of EPA, the July 1997 Final CSO Facilities Plan and Environmental Impact Report (FEIR) included a chapter that reviewed the technology-based assessments of alternatives for projects that had been granted Phase I waivers. In addition, the FEIR included the results of receiving water modeling conducted for the Alewife Brook/Upper Mystic River receiving waters. The receiving water modeling confirmed the supposition from the SMP that stormwater would prevent the attainment of water quality standards for fecal coliform bacteria even if CSO were totally eliminated. The modeling further indicated that water quality standards are not met in Alewife Brook during dry weather. These data supported the recommended plan for providing control of the 3-month storm, by demonstrating that higher levels of control would not provide a measurable benefit in terms of attainment of water quality standards.

4. **DEP Issues Temporary Variance from Water Quality Standard.** On December 31, 1997, DEP, in accordance with Massachusetts Water Quality Standards regulations, issued water quality standards determinations that allowed the LTCP to be implemented. A water quality standards determination by DEP was required for any receiving water where CSO discharges would remain under the recommended plan. The DEP determinations were approved by EPA on February 27, 1998, paving the way for implementation of the LTCP. DEP's determinations included decisions to issue short-term, CSO-related variances to water quality standards for the Charles River and for Alewife Brook/Upper Mystic River.

5. **Cambridge Begins to Implement 1997 Plan.** One of the Alewife Brook projects recommended in the 1997 plan had called for the separation of combined stormwater and sanitary sewer systems in two large areas of Cambridge (CAM002 and CAM004), to remove stormwater flows from the overburdened sewer system. The primary intent of the project was to reduce combined sewer overflows to Alewife Brook. A key element of the separation projects was that, to the extent feasible, the existing combined sewers would be converted to separate storm drains, by removing sanitary connections.

   In compliance with the federal court schedule, the City of Cambridge, under a financial assistance agreement with MWRA, commenced design of the CAM002 and CAM004 sewer

separation project in January 1997 and commenced construction of the initial phases of the work in July 1998.

As discussed above, MWRA and the City of Cambridge used available Cambridge infrastructure plans to estimate the scope and cost of the project, which were the basis for evaluating and selecting the project as an appropriate component of the long-term CSO plan. However, as Cambridge proceeded to design and construct the project, new information about the condition of the Cambridge sewer and stormwater systems and the requirements for separation became evident.

In 1997-1999, during extensive field investigations to support design of the project, the City of Cambridge collected new information about the configuration and condition of its stormwater and sanitary systems. The new information indicated that in certain locations the combined sewer systems in Cambridge were very different from record plans that had been used to develop the CSO plan. It also became clear that the existing combined sewers had insufficient hydraulic capacity to provide an appropriate level of storm drainage service. Thus, instead of converting existing combined sewers to storm drains, a significant degree of new, larger-capacity storm drainage piping was required. From this new information, Cambridge determined that the scope and cost of the work to separate sewers and achieve the established CSO control goals would be much greater than originally assumed. Cambridge estimated that the cost of the project could be as much as $75 million, compared to the original (1997) estimate of $12.1 million.

6. **MWRA Reassesses Level of CSO Control; Cambridge Addresses Stormwater Detention Issue.** Based on the new information from field investigations in Cambridge, it was no longer certain that the proposed project represented the most cost-effective level of CSO control for Alewife Brook. The B_{cso} water quality standard requires that "the highest level of control must always be achieved for each case as determined in the facilities plan through a cost/benefit analysis" (DEP *Policy for Abatement of Pollution from Combined Sewer Overflow*). Therefore, it became necessary for MWRA to reevaluate the long-term CSO control plan for Alewife Brook.

The purpose of the reevaluation was to compare a range of CSO control technologies and determine an appropriate, cost-effective level of control. The reevaluation confirmed the original conclusion that targeted sewer separation is the most cost-effective means to control CSO discharges to Alewife Brook, but revised the scope of the recommended sewer separation. Elements of the original 1997 recommended plan are compared with the revised recommended plan in Table 2-1. Figure 2-2 presents the original 1997 recommended plan, and Figure 2-3 presents the revised recommended plan.

As indicated in Table 2-1, sewer separation in the CAM004 area was still recommended, however the city of Cambridge determined that they would need to construct a new stormwater outfall to the Little River to convey the peak stormwater flows from the proposed area to be separated. Cambridge also proposed construction of a vegetated wetland detention basin within the Metropolitan District Commission (MDC) Alewife Brook Reservation, adjacent to the Little River, to detain and attenuate the peak stormwater flows, thereby minimizing impacts on flood elevations in Alewife Brook. While Cambridge has already constructed a small portion of the sewer separation work originally recommended in the CAM002 area, the revised plan no longer included CAM002 sewer separation. Rather, it proposed sewer separation in the CAM400 area instead. The revised plan also recommended a set of localized hydraulic improvements that would reduce overflows at other CSO outfall locations in Cambridge and Somerville.

With the new system information, as well as updated wet weather flow data collected in 1999, MWRA developed new estimates of existing CSO discharge frequency and volume. The estimate of existing annual CSO volume from all outfalls along Alewife Brook increased from 18 million gallons presented in the 1997 plan to 50 million gallons, and the estimate of overflow activation frequency increased from 16 to 63 times per year. Table 2-2 presents the predicted reduction in annual CSO frequency and volume to Alewife Brook for the original 1997 plan and the revised recommended plan. As indicated in Table 2-2, the revised recommended plan was predicted to attain the same annual percent reduction in CSO volume as the original plan. It should be noted that the MWRA and City of Cambridge have already

TABLE 2-1. COMPARISON OF 1997 RECOMMENDED PLAN AND THE REVISED RECOMMENDED PLAN FOR ALEWIFE BROOK CSO CONTROL

1997 Recommended Plan[1]	Revised Recommended Plan[1]
• Separate sewers in the CAM004 tributary area to reduce CSO discharges • Separate sewers in the CAM002 tributary area to eliminate CSO discharges	• Separate sewers in the CAM004 tributary area to eliminate CSO discharges (includes construction of a new stormwater outfall and wetland detention basin • Increase size of local sewer connection at CAM002, CAM401B and SOM01A, to reduce CSO discharges at these locations • Increase size and capacity of Rindge Avenue siphon to reduce CSO discharges at CAM401A; add hydraulic relief gate at MWR003 • Separate sewers in the CAM400 tributary area and close outfall
Floatables control at remaining CSO outfalls (SOM01A, CAM001, CAM004, CAM400, CAM401, MWR003)	• Floatables Control at remaining CSO outfalls (SOMA001A, CAM001, CAM002, CAM004[2], CAM401A, CAM401B and MWR003)
Estimated Capital Cost: $12.1 M	Estimated Capital Cost: $73.7 M

(1) Both the 1997 plan and the new plan include separation of "baffle" manholes in Somerville, to eliminate CSO discharges at outfalls SOM001 and SOM002. In addition, with funding from the MWRA SOP program, SOM002A, SOM003 and SOM004 were closed. The City of Somerville completed this work between 1994 and 1996.

(2) Temporary floatables control will be provided at Drain Vault No. 5 (CAM004) until the regulator is closed following completion of upstream sewer separation.

moved forward on the construction of the downstream portion of the CAM004 sewer separation project, based on the judgment that this work would be a common element of any long-term plan for Alewife Brook (separation of the CAM004 area allows closure of outfall CAM004; creates additional interceptor capacity that allows reduction in CSO volume at other outfalls; and protects the Fresh Pond water supply from potential contamination from surcharging combined sewers). As a result of the construction of the downstream portion of the CAM004 separation project, significant reductions in the activation frequency and volume of CSO to Alewife Brook have already been achieved. The annual average CSO

SOURCE ATLAS OF CAMBRIDGE, CITY OF CAMBRIDGE WEB SITE

01e/6623/Zpc91ww

FIGURE 2-2.
ORIGINAL MWRA 1997 RECOMMENDED PLAN FOR
ALEWIFE BROOK CSO CONTROL

SOURCE ATLAS OF CAMBRIDGE, CITY OF CAMBRIDGE WEB SITE

01f/6623/Zpc91ww

FIGURE 2-3.
PROPOSED REVISED RECOMMENDED PLAN FOR
ALEWIFE BROOK CSO CONTROL

TABLE 2-2. COMPARISON OF PREDICTED CSO REDUCTION FOR THE 1997 RECOMMENDED PLAN AND THE REVISED RECOMMENDED PLAN

1997 Recommended Plan

	Activation Frequency*	Annual CSO Volume (mg)*	% Volume Reduction
Assumed Existing Conditions	16	18.3	-
Recommended Plan	4	2.9	84%

Revised Recommended Plan

	Activation Frequency*	Annual CSO Volume*	% Volume Reduction
Updated Existing Conditions	63	49.7	-
Recommended Plan	7	7.4	84%

* in a Typical Rainfall Year

activation frequency has already been significantly reduced from 63 to 25, and the total annual volume has been reduced from 50 to 33 million gallons.

MWRA believes that this revised plan is the most cost-effective long-term plan for CSO control for Alewife Brook, and that providing higher levels of CSO control would not yield significant water quality benefits despite significantly higher costs. MWRA is now recommending this plan to satisfy existing federal and state regulatory requirements and federal court obligations.

DEP Regulatory Process

7D. DEP Issues Variance in 1999, and Extends it through September, 2003. On March 5, 1999, DEP issued a three-year CSO variance for Alewife Brook/Upper Mystic River to MWRA and the cities of Cambridge and Somerville. The variance included conditions that required MWRA and the cities to conduct additional investigations relative to CSO and stormwater discharges, and required MWRA to implement the CSO control plan presented in the FEIR. The variance was subsequently extended to September 5, 2003, and supplemental conditions were added. The conditions of the original variance are summarized in Table 2-3, and the additional conditions of the variance extension are summarized in Table 2-4. At the time the variance was originally issued, the EPA also issued Section 308 enforcement letters to all cities and towns discharging stormwater to Alewife Brook and Upper Mystic River (above Amelia Earhart Dam). This enforcement action required each city and town to conduct investigations of their stormwater systems, perform stormwater sampling and analysis, identify illicit sanitary cross connections and take corrective measures.

8D. MWRA to Submit Final Alewife Variance Report to DEP The information collected during the variance period, including watershed information collected by other parties (EPA. DEP, Mystic River Watershed Association and others) has been used to reevaluate CSO control alternatives and associated water quality benefits. This information is presented in subsequent chapters of this report, which was submitted to DEP on July 1, 2003.

9D. DEP Review of Final Variance Report DEP will review the technical/engineering, water quality, cost, and affordability information presented in this report. During this review period, DEP intends to conduct a public forum on water quality and level of CSO control issues. Following the review period, DEP will either (a) accept the report's proposed level of CSO control, in which case DEP will proceed to reclassify the water quality standards from Class B to Class B_{CSO}, or (b) not accept the proposed level of CSO control, and require an increased level of control. If DEP finds that MWRA/Cambridge should proceed to a higher level of CSO control than what is proposed in the Final Variance Report, the agency can either require MWRA/Cambridge to proceed with complete sewer separation (in which case the waters will remain Class B); or the agency can require a higher level of control that does not eliminate CSO discharges (in which case the receiving waters must be reclassified B_{CSO}).

TABLE 2-3. CSO VARIANCE CONDITIONS

Description of Condition	Responsible Party
A. Actions to Minimize CSO/Sanitary Discharges	
Implement Nine Minimum Controls, and elements of the revised recommended plan per the April 2001 NPC	MWRA, Cambridge, Somerville
Submit a workplan to provide improved public notification on CSO discharges and potential impacts	MWRA, Cambridge, Somerville
Provide estimates of AB/UMR CSO activations and volumes over the Variance period; Submit workplan for method of reporting activations	MWRA, Cambridge, Somerville
Reevaluate possibility of additional infiltration/inflow controls at key locations	MWRA
Identify opportunities for additional SOP measures in local combined systems and assess likely water quality benefits	Cambridge, Somerville, MWRA
(For Alewife/Upper Mystic sewer member communities) Provide MWRA BMP plan, GIS sewer system mapping, technical assistance as requested, and review community stormwater management plan to identify opportunities for enhanced pollution prevention, if requested.	MWRA
B. Actions to Further Assess CSO/Stormwater Pollutant Loads	
Receiving water sampling for AB/UMR over the Variance period to assess impacts of CSO discharges; submit report annually with results	MWRA
Stormwater sampling at representative stormdrain locations to allow for determinations of stormwater loadings	MWRA, Cambridge, Somerville
CSO sampling at two locations for two storm events	MWRA
C. Assessment of CSO Controls in the Alewife/Upper Mystic Basin	
Prepare and file final report summarizing and assessing information gathered during Variance process, including a description of the local combined sewer systems, a reassessment of the CSO control plan for Alewife/Upper Mystic, a final recommended CSO control plan for Alewife/Upper Mystic, and an assessment of financial impact of the revised plan	MWRA
Identify "triggers" appropriate for basis to determine when additional CSO controls would yield greater benefits for respective costs	MWRA (with EPA and DEP)

regard to the level of CSO control, MWRA acknowledged the desire of many residents to eliminate CSO to Alewife Brook. However, MWRA maintains that the level of control presented for the revised recommended plan in the NPC represents the most cost-effective and appropriate level of control for Alewife Brook at this time. MWRA further noted that the MEPA process for the NPC will not result in a final determination of the level of CSO control for Alewife Brook. This determination will be made by DEP following submittal of this final variance report for Alewife Brook/Upper Mystic River.

With regard to the issues of flooding and the layout of the detention basin, the city of Cambridge undertook extensive work following receipt of the Secretary's Certificate on the NPC to address these issues. More detailed modeling was conducted to gain a more accurate picture of the hydraulics of the stormwater system, and to refine the layout of the stormwater detention basin. The result of this work was a revised layout of the detention basin, and the conclusion that the sewer separation work will not result in an increase in peak flow to Alewife Brook.

9M. Response to Comments (RTC) to be Submitted to MEPA. The RTC was submitted to MEPA in May 2003. It is MWRA's understanding that submittal of the RTC satisfies the requirements specified in the MEPA Certificate on the NPC.

Section Three

CHAPTER THREE
DESCRIPTION AND UPDATE OF BASELINE COLLECTION SYSTEM CONDITIONS

As specified in the conditions of the Alewife Brook/Upper Mystic River Variance, this chapter presents a summary description of the wastewater collection systems in Cambridge and Somerville, and the MWRA transport system associated with the Alewife Brook area (generally referred to as the "Alewife Subsystem". The descriptions reflect system conditions as of 2003, based on information currently available. The focus of the collection system description is on the parts tributary to the CSO regulators. Following the system description, a description of the collection system model used to develop and evaluate the CSO control alternatives is presented.

DESCRIPTION OF ALEWIFE SUBSYSTEM

The Alewife subsystem includes eight CSO outfalls, two MWRA interceptors, and the MWRA's Alewife Brook Pumping Station. The description of the Alewife subsystem will start with the MWRA's transport facilities, then move to a description of the systems tributary to each of the CSO outfalls. The locations of outfalls and other principal wastewater collection and transport facilities in the Alewife Brook/Upper Mystic River subsystem are shown on Figure 3-1A (in map pocket). The locations of the outfalls tributary to Alewife Brook are shown in more detail in Figure 3-1B (in map pocket).

MWRA Transport Facilities

The downstream hydraulic control point for the Alewife subsystem is the MWRA's Alewife Brook Pumping Station. The Alewife Brook Pumping Station is located at the intersection of the Mystic Valley and Alewife Brook Parkways in Somerville. The pumping station features three 26 mgd pumps and one 12 mgd pump, along with a gravity bypass. The 26 mgd pumps and the gravity bypass discharge to the North Metropolitan Relief Sewer (NMRS), and the 12 mgd pump

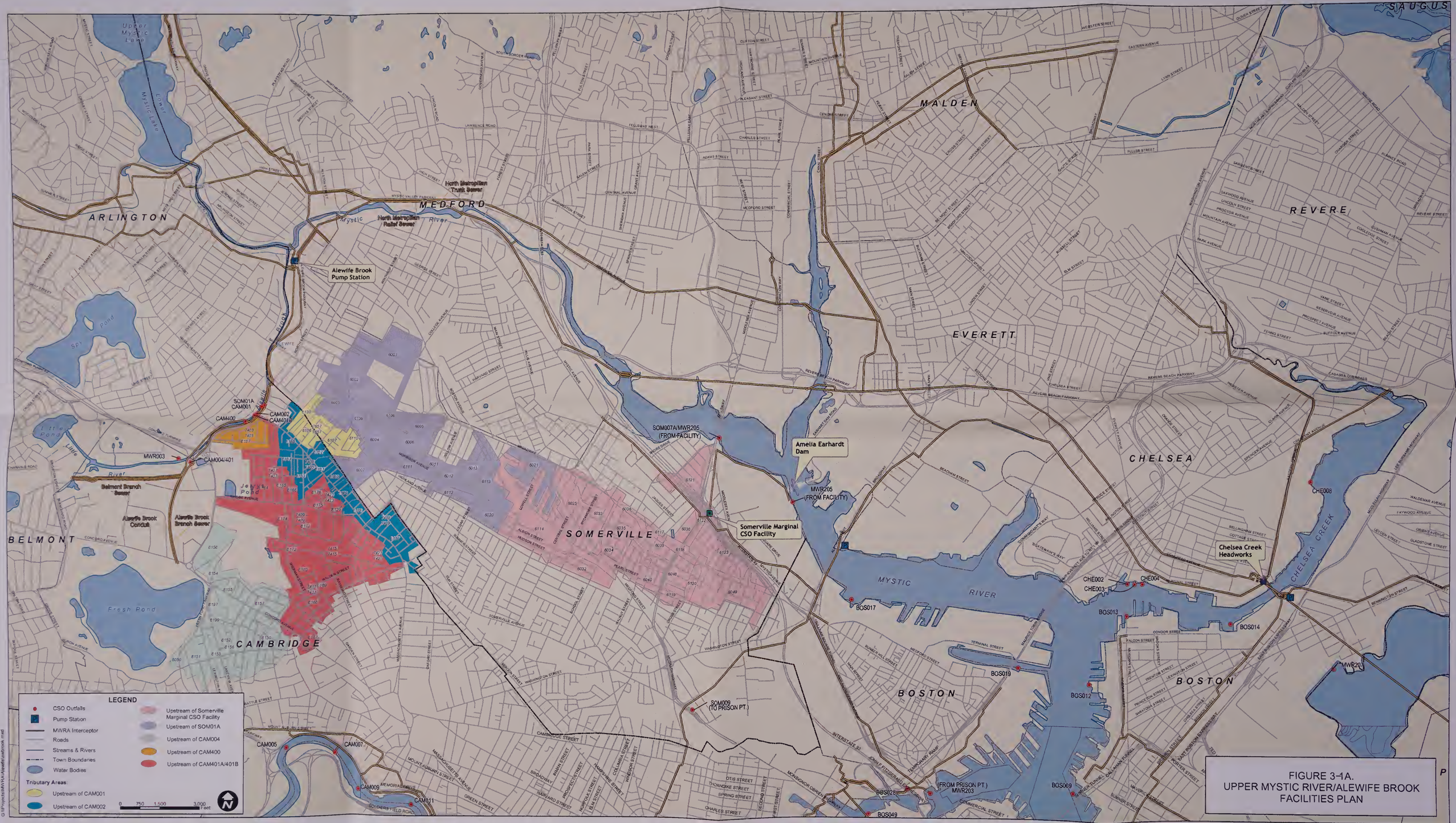


FIGURE 3-1A.
UPPER MYSTIC RIVER/ALEWIFE BROOK
FACILITIES PLAN

SOURCE: ATLAS OF CAMBRIDGE, CITY OF CAMBRIDGE WEB SITE

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FIGURE 3-1B. LOCATION OF CSO OUTFALLS TO ALEWIFE BROOK, WITH CSO REGULATORS AND TRIBUTARY AREAS

discharges to the North Metropolitan Trunk Sewer (NMTS). The NMTS and NMRS are tributary to the Chelsea Creek Headworks.

As described further below, available flow records indicate that the maximum pumping capacity at Alewife Brook Pumping Station is approximately 75 mgd. In wet weather, the peak pumping capacity is limited by the hydraulic grade line downstream in the North Metropolitan system. Alternatives to optimize the operation of Alewife Brook Pumping Station are described in Chapter Five.

The two MWRA interceptors tributary to the Alewife Brook Pumping Station are the Alewife Brook Conduit (ABC), and the Alewife Brook Branch Sewer (ABBS). The ABC starts as a 48-in. diameter pipe at the connection to the local Cambridge sewer behind the Ground Round restaurant. The ABC receives separate sanitary flow and inflow from Belmont via a connection to the Belmont Branch Sewer upstream of regulator RE031. The ABC increases to 66-in. at this location and continues as a 66-in. conduit to the Alewife Brook Pumping Station. A direct relief of the ABC is provided at regulator RE031, which discharges to outfall MWR003. The ABC receives combined flow from a series of CSO regulators in Cambridge and one CSO regulator in Somerville. The ABC also receives separate sanitary flow and inflow from three local connections from Somerville, three local connections from Arlington, and from a connection to the Lexington Branch Sewer, which serves Lexington and Arlington.

The ABBS starts as an 18-in. conduit at the connection to the local system behind the Ground Round restaurant. The ABBS increases to 23x33-in. in the vicinity of regulator RE032, located at the downstream end of the Rindge Avenue combined sewer. This regulator overflows to the ABC at regulator RE031. The ABBS and ABC are interconnected again approximately 1,000-ft. downstream of regulators RE031 and 032, and the ABBS increases in size to 27x35-in. The ABBS increases to 29x37-in. near Foch Street. It increases to 35x42-in. near Broadway in Somerville, and continues with this cross section to the Alewife Brook Pumping Station. The ABBS receives combined flow from CSO regulators in Cambridge, and through the cross-connections with the ABC.

Because the ABC and ABBS both extend upstream from the Alewife Brook Pumping Station and are interconnected upstream, both exhibit similar hydraulic profiles during wet and dry weather. During sufficient storm events, both lines may surcharge due to the downstream pumping station capacity limitations.

CSO Community Collection Systems

Of the eight CSO outfalls associated with the Alewife subsystem, six provide relief for the Cambridge system, one provides relief for the Somerville system, and one provides direct relief of the MWRA's interceptor system. Some of the regulators serving the Cambridge system may also relieve the MWRA's interceptor system under certain conditions. Following is a description of collection systems tributary to each CSO outfall in the Alewife subsystem.

Outfall CAM001. Outfall CAM001 discharges to the Alewife Brook north of Massachusetts Avenue at the extension of Foch Street.

RE011. This regulator is a high outlet type, located on the 15-in. Foch Street CS adjacent to the Alewife Brook Parkway (Figure 3-2). RE011 conveys undiverted flow to the 66-in. ABC via a 15-in. connection. When the depth of flow in the regulator exceeds the weir elevation of 110.0 (MDC base) due to incoming flow or surcharging in the ABC, overflow is diverted to the 16-in. overflow conduit tributary to CAM001. Based on a 5-year storm peak river elevation of approximately 109.15 and a 10-year storm peak river elevation of 111.12, backflow from Alewife Brook into the ABC could occur in the 10-year storm.

The approximately 4-acre tributary area upstream of RE011 is served by separate sanitary pipes and storm drains in an over/under configuration with common manholes. Cross-connections between the two systems likely occur at the common manholes. An interconnection with the SOM01A system exists in the upstream reach of the RE011 system.

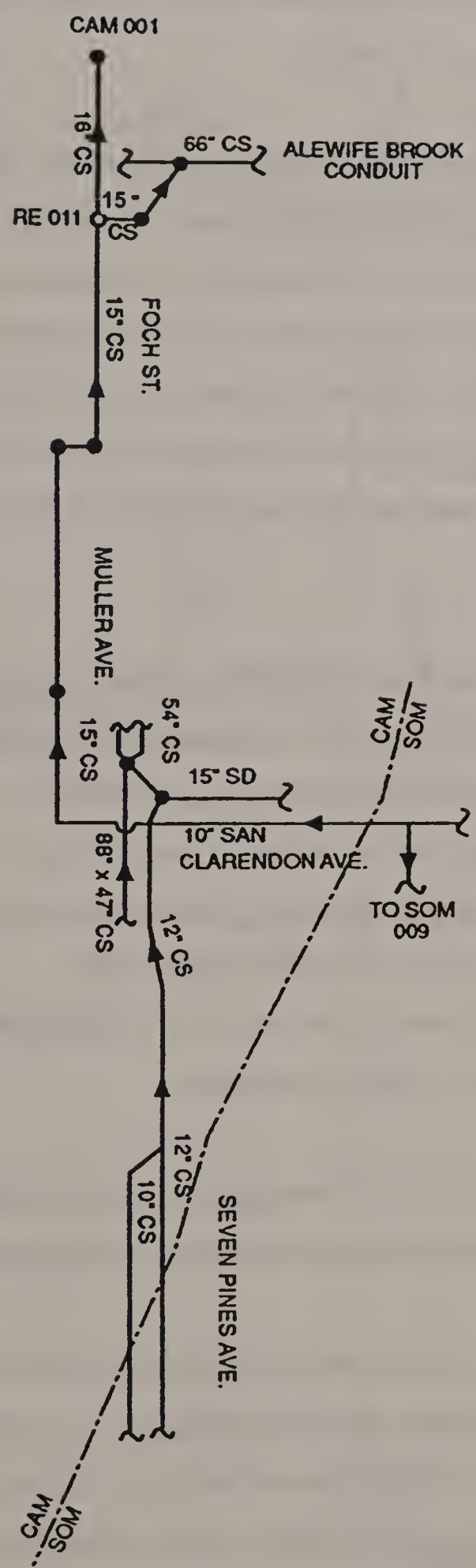

FIGURE 3-2. SCHEMATIC OF OUTFALL CAM001

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Outfall CAM002. Outfall CAM002 discharges to the Alewife Brook at the Massachusetts Avenue bridge.

RE021. This regulator is a high outlet type located on the 36x42-in. Massachusetts Avenue CS adjacent to Alewife Brook (Figure 3-3). RE021 conveys undiverted flow to the 27x35-in. ABBS via a 15-in. connection. When the depth of flow in the regulator exceeds the weir elevation of 112.35 (MDC base) due to incoming flow or surcharging in the ABBS, overflow is diverted to the 34x46-in. overflow conduit tributary to CAM002. The weir elevation is above the elevation of the 25-year flood in Alewife Brook. The total combined area tributary to RE021 is approximately 89 acres.

Sewer separation work has been completed in certain areas upstream of regulator RE021. The Orchard Street area was separated, and the sanitary pipes and storm drains were re-connected to the Massachusetts Avenue CS. Further separation is planned for the side streets in Cambridge on the north side of Massachusetts Avenue. A separate 18-in. sanitary pipe runs along Massachusetts Avenue parallel to and north of the combined sewer, and ties directly into the ABBS. A second sanitary line runs parallel to the combined sewer on the south side of Massachusetts Avenue. This sanitary pipe ties into the CAM401B regulator.

Outfall MWR003. Outfall MWR003 discharges to the Little River just upstream of the confluence with Alewife Brook, behind the Alewife MBTA Station and Garage.

RE031. This regulator is a side weir type, located on the 66-in./54-in. ABC adjacent to the Alewife MBTA Station and Garage (Figure 3-4). The outlet from the regulator is a 54-in. circular pipe. RE031 also receives incoming flow from the 24-in. overflow relieving the Belmont Junction Structure, and incoming flow from the 30-in. overflow

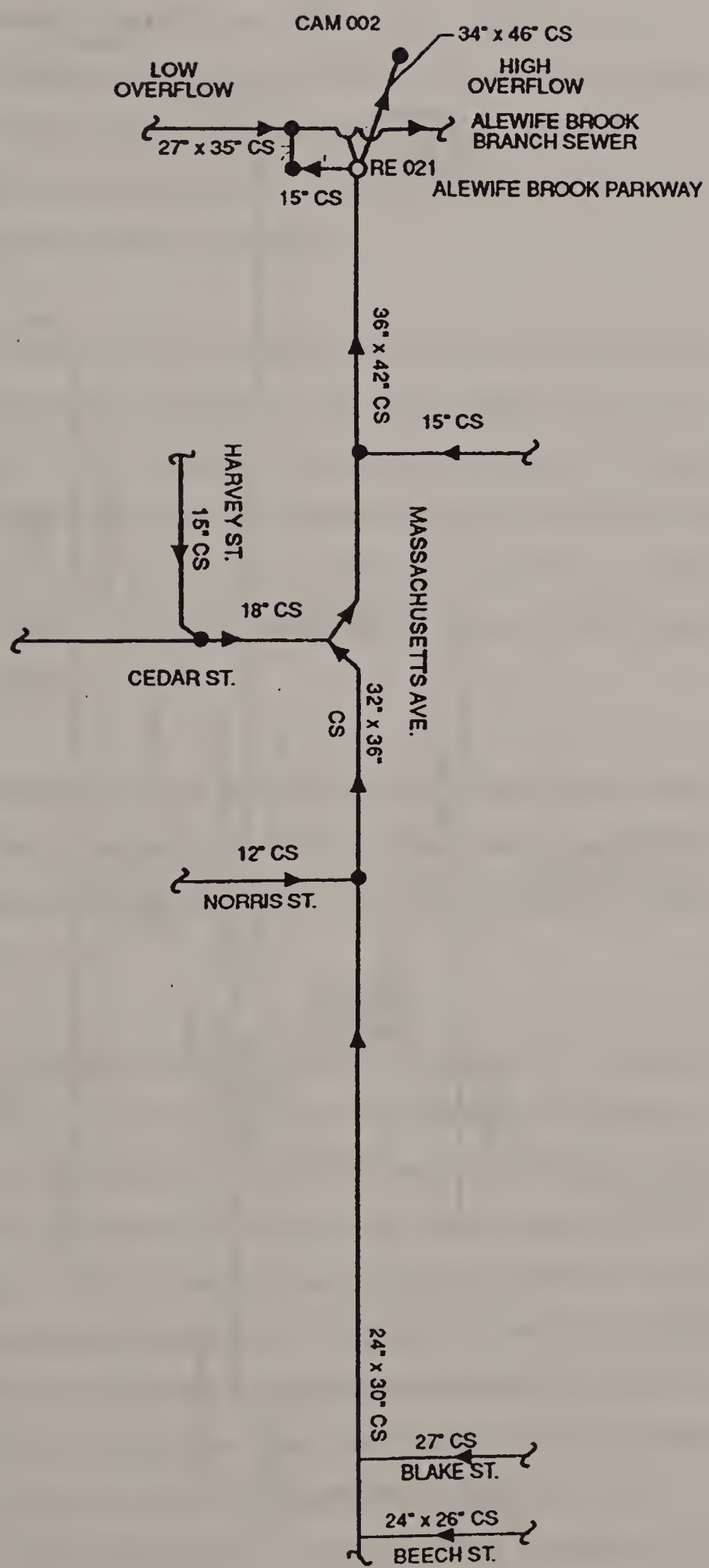

FIGURE 3-3. SCHEMATIC OF OUTFALL CAM002

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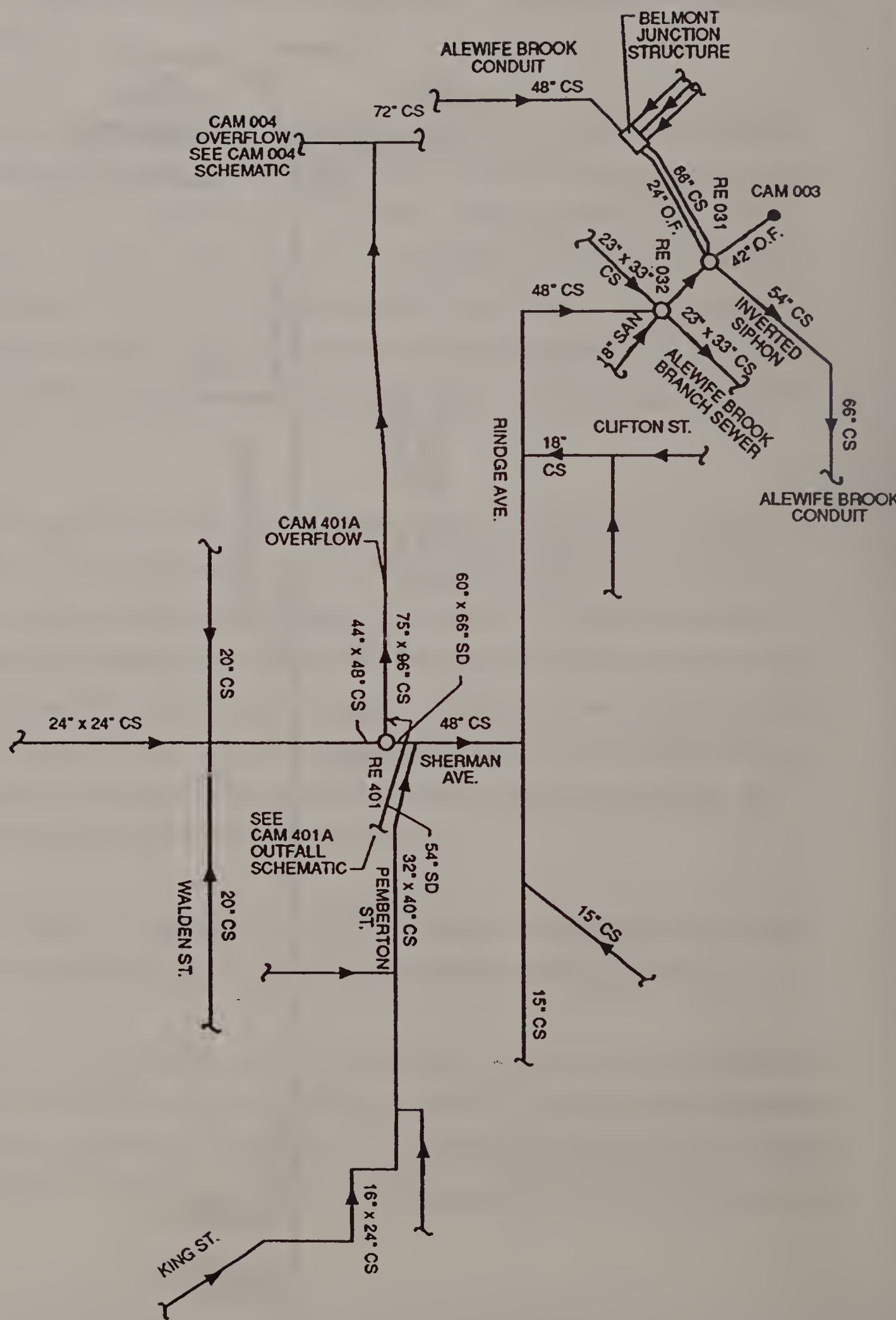

FIGURE 3-4. SCHEMATIC OF OUTFALL MWR003

conduit relieving RE032. When the depth of flow in the regulator exceeds the weir elevation of 111.0 due to surcharging in the ABC, overflow is diverted to the 42-in. overflow conduit to MWR003. In extreme storm events, MWRA field crews may remove stop planks in RE031 to provide further relief of the interceptor system. The weir elevation with stop planks in place is just below the 10-year river elevation of 111.15, indicating that river inflow could occur in the 10-year storm.

RE032. This regulator is a high outlet type, located on the 23x33-in. ABBS adjacent to the Alewife MBTA Station and Garage (Figure 3-4). The regulator also receives flow from the 48-in. Rindge Avenue CS, and from an 18-in. sanitary pipe serving the MBTA station. The invert of the 30-in. circular overflow is 5.6 ft. above the invert of interceptor. When the depth of flow in the regulator exceeds 5.6 ft. due to incoming flow or surcharging in the ABBS, overflow is diverted to the 30-in. overflow conduit tributary to RE031 and MWR003.

Outfall CAM004. Outfall CAM004 discharges to a shallow channel that forms the day-lighted upper reach of Alewife Brook just upstream of the confluence with the Little River, behind the Alewife MBTA Station and Garage. Outfall CAM401 also discharges at this location (see description below).

RE041. This regulator has been functionally replaced by drain vault No. 5 as part of the work completed by the City of Cambridge to date along Fresh Pond Parkway (Figure 3-5). In addition to drain vault No. 5, a new box drain (6x4-ft. stepping up to 10x4-ft.) has been constructed in Concord Avenue parallel to the existing 38x42-in. combined sewer. In the future, the box drain will convey separate stormwater runoff from the CAM004 tributary area to Alewife Brook. However, currently the CAM004 tributary area remains combined and there is measurable dry weather flow in the new box drain. During dry weather conditions, the flow is conveyed to the existing 38x42-in. combined sewer via a temporary 24x30-in. connection just upstream of the entrance to the drain vault. Flow in the 38x42-in. combined sewer, including the dry weather flow from the box drain, is connected directly to the 48-in. ABC. Wet

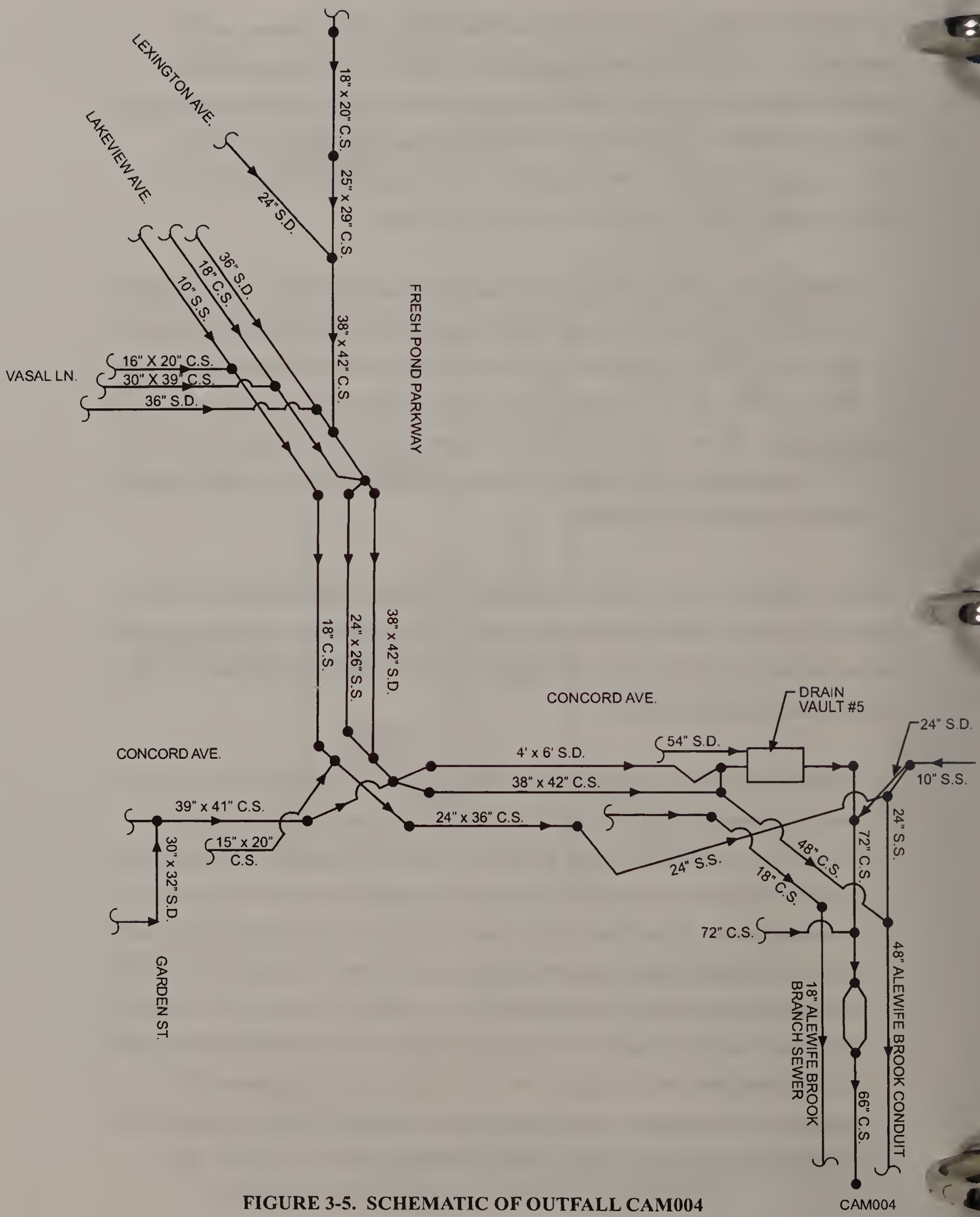

FIGURE 3-5. SCHEMATIC OF OUTFALL CAM004

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weather flows in the box drain that exceed the hydraulic capacity of the temporary dry weather connection pass over a weir at elevation 109.27 (MDC base) in Drain Vault No. 5 and out through the existing outfall to Alewife Brook. Based on a 5-year storm river elevation of 109.15, it appears that river inflow through Drain Vault No. 5 could occur in storms larger than the 5-year storm. Part of the CAM004 separation project may include a flap gate to prevent river inflow into Drain Vault No. 5. The total combined area tributary to Drain Vault No. 5 is approximately 214 acres.

Outfall CAM400. Outfall CAM400 discharges to the Alewife Brook south of Massachusetts Avenue at the extension of Harrison Avenue.

RE400. This regulator is a transverse weir type located adjacent to the Alewife Brook Parkway opposite Harrison Avenue (Figure 3-6). RE400 receives flow from a 30-in. SD and 10-in SAN, and conveys undiverted flow to the 66-in. ABC via a 10-in. connection. When the depth of flow in the regulator exceeds the weir elevation of 109.42 (MDC base) due to incoming flow or surcharging in the interceptor, overflow is diverted to the 30-in. overflow conduit tributary to CAM400. Based on a 5-year storm river elevation of 109.15, it appears that river inflow through regulator RE400 could occur in storms larger than the 5-year storm.

The approximately 14-acre tributary area upstream of RE400 is served by separate sanitary pipes and storm drains in an over/under configuration with common manholes. Cross-connections between the two systems likely occur at the common manholes.

Outfall CAM401A. Outfall CAM401A discharges to a shallow channel that forms the day-lighted upper reach of Alewife Brook, just upstream of the confluence with the Little River, behind the Alewife MBTA Station and Garage. Outfall CAM004 also discharges at this location.

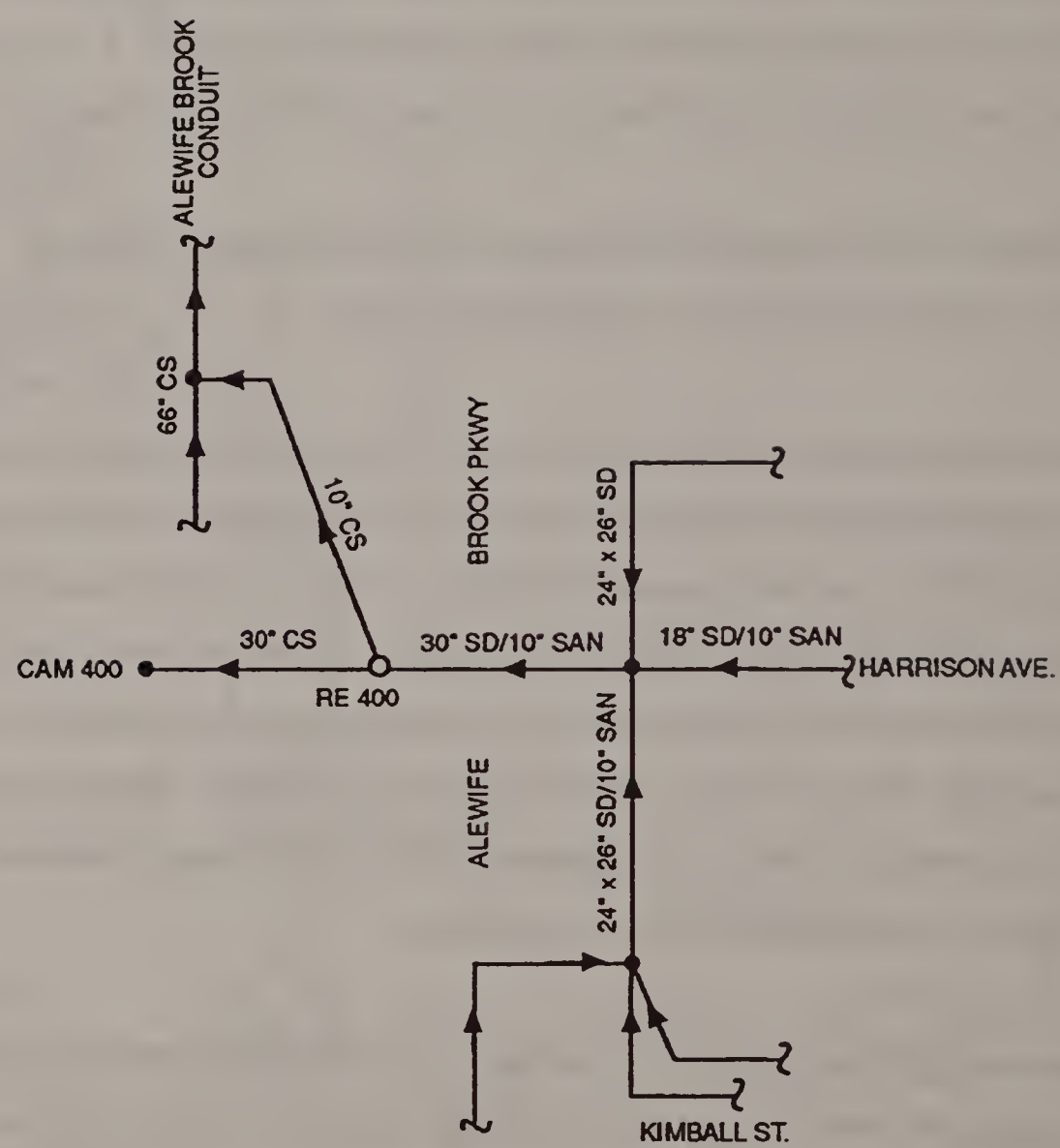


FIGURE 3-6. SCHEMATIC OF OUTFALL CAM400

RE401A - This regulator is a side weir type, located on the 44x48-in. Sherman Street CS between Bellis Circle and Pemberton Street (Figure 3-7). RE 401a conveys undiverted flow up the Sherman Street 60x66-in. SD, past the 54-in. Pemberton Street SD and on to RE 032 via the 48-in. Rindge Avenue CS. When the depth of flow in the regulator exceeds the weir elevation of 112.11 due to incoming flow or backwater from the Rindge Avenue CS, overflow is diverted to the 75x96-in. overflow conduit tributary to CAM004. The total combined area potentially tributary to regulator RE401A is 250 acres. Some portion of inflow from this area, however, is diverted to outfall 401B through cross connections with the sanitary pipe that runs from that area through Cottage Park to Massachusetts Avenue. The weir elevation in RE401A is just over the 25-year flood elevation in Alewife Brook.

Outfall CAM401B. Outfall CAM401B discharges to the Alewife Brook on the south-west side of Massachusetts Avenue at the intersection with Alewife Brook Parkway immediately upstream of CAM002.

RE401B. This regulator is a high outlet type located on the 41.88x32.75-in. sanitary pipe on the south side of Massachusetts Avenue (Figure 3-8). RE401B conveys undiverted flow to the ABC via a 10-in. connection. When the depth of flow exceeds the weir elevation of 110.28 ft. (MDC datum), due to incoming flow or surcharging in the ABC, overflow is diverted to the 30-in. overflow conduit to CAM401B. The tributary area upstream of RE401B is indicated on the city of Cambridge sewer system maps as a separate sanitary system, but flow metering indicates a significant quantity of inflow is tributary to the regulator through cross-connections to the combined area upstream of outfall 401A area. River inflow could occur through RE401B between the 5-year and 10-year storms.

Outfall SOM01A. Outfall SOM01A discharges to Alewife Brook just north of the Massachusetts Avenue bridge. The outfall discharges to a short channel that feeds into Alewife Brook. Outfall SOM01A is the outlet to the Tannery Brook Drain.

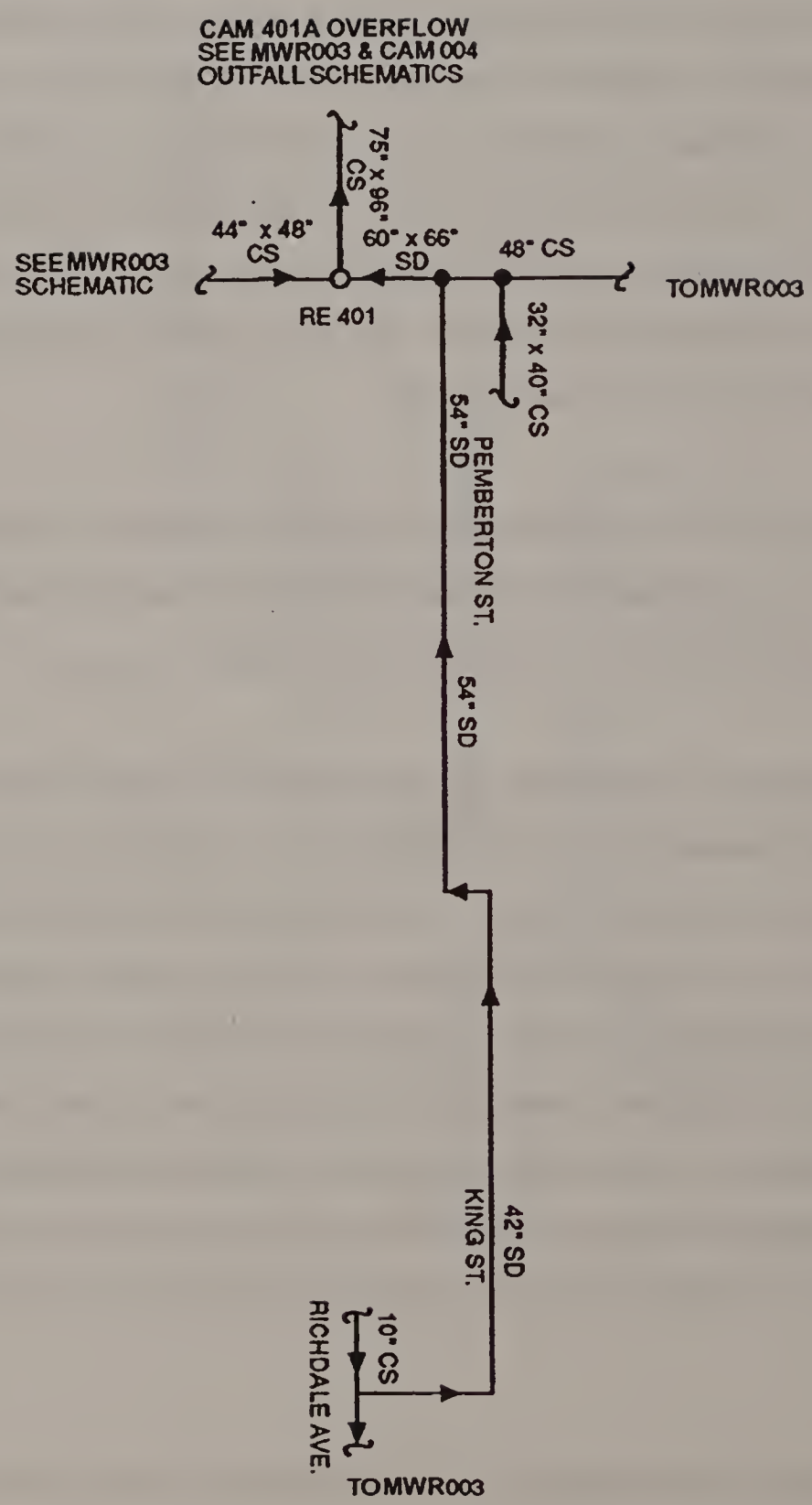


FIGURE 3-7. SCHEMATIC OF OUTFALL CAM401A

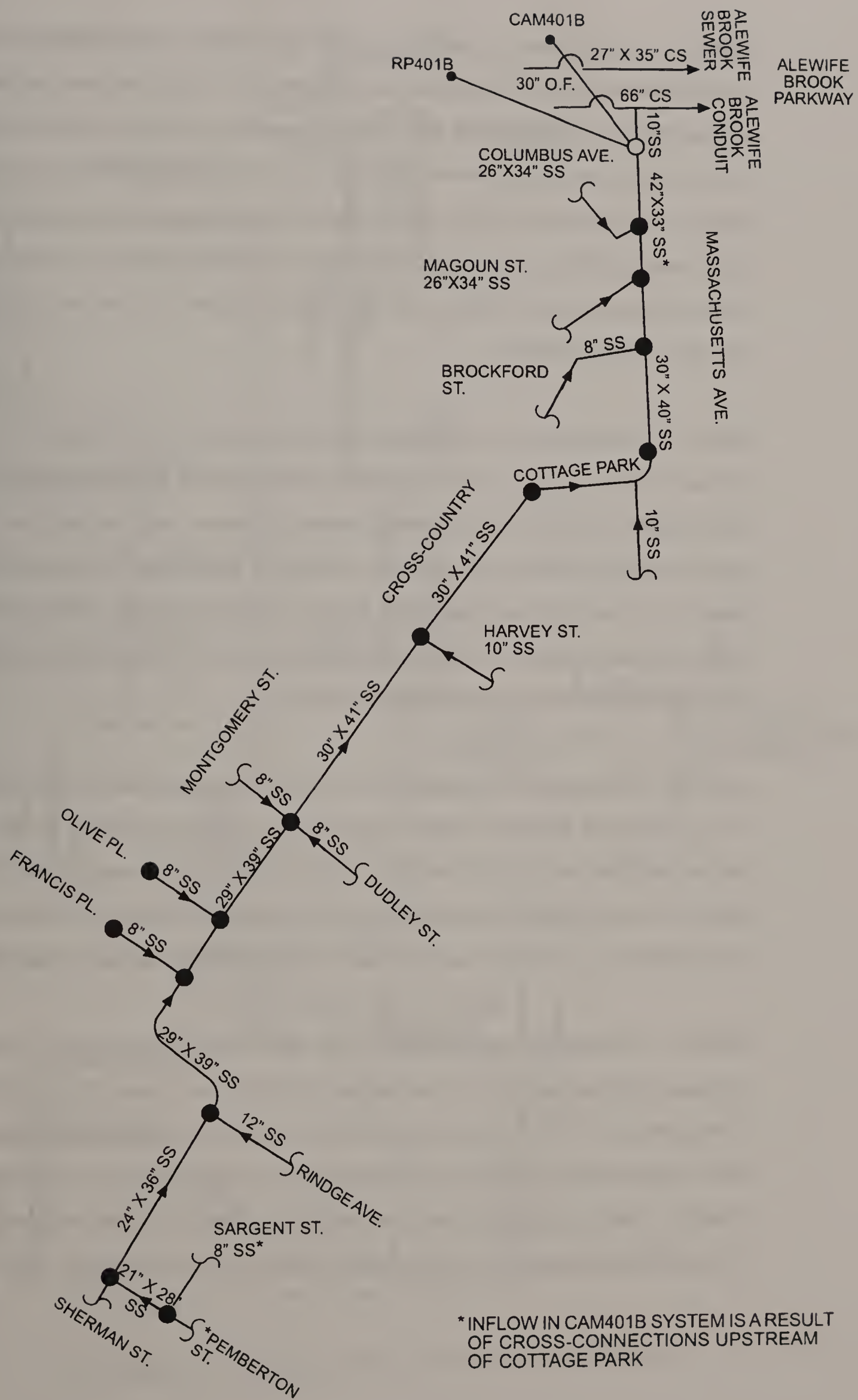


FIGURE 3-8. SCHEMATIC OF OUTFALL CAM401B

RE01A. This regulator is a restricted outlet type located on the 54x96-inch Tannery Brook Drain at Alewife Brook Parkway (Figure 3-9). An 18-inch vertical orifice conveys undiverted flow to the 66-inch ABC. When the depth of flow exceeds the weir elevation of 111.0 due to incoming flow or surcharging in the ABC, overflow is diverted to outfall SOM01A. Upstream of RE01A, the Tannery Brook Drain receives combined sewage from a series of five regulators in Somerville, separate drainage flow, and sanitary flow from localized sanitary systems. During a 10-year storm, river inflow could occur through regulator RE01A.

RE011. This regulator is a side-outlet weir type, located on the 24x17-inch Morrison Avenue combined sewer at its intersection with Highland Road (Figure 3-9). Downstream of RE011, the Morrison Avenue CS conveys undiverted flow through RE012 to the Elm Street CS, with flow eventually discharging to the Cambridge Branch Sewer via a connection at Somerville Avenue and Poplar Street. When the depth of flow in the regulator exceeds 1.85 feet, overflow is diverted to a 24-inch conduit tributary to the Tannery Brook Drain and regulator RE01A.

RE012. This regulator is a side outlet weir type, located on the 24x28-in. Grove Street CS, just south of Winslow Avenue (Figure 3-9). The Grove Street CS conveys undiverted flow to the Elm Street CS, which is ultimately tributary to the Cambridge Branch Sewer. When the depth of flow in the regulator exceeds 2.0 feet, overflow is diverted to a 30-in. pipe tributary to the Tannery Brook Drain and regulator RE01A.

RE013. This regulator is a side-outlet weir type, located on the 24x17-inch Morrison Avenue combined sewer at its intersection with Willow Avenue (Figure 3-9). Downstream of RE013, the Morrison Avenue CS conveys undiverted flow through RE012 to the Elm Street CS, with flow eventually discharging to the Cambridge Branch Sewer. When the depth of flow in the regulator exceeds 1.3 feet, overflow is diverted to a 24-inch conduit tributary to the Tannery Brook Drain and regulator RE01A.

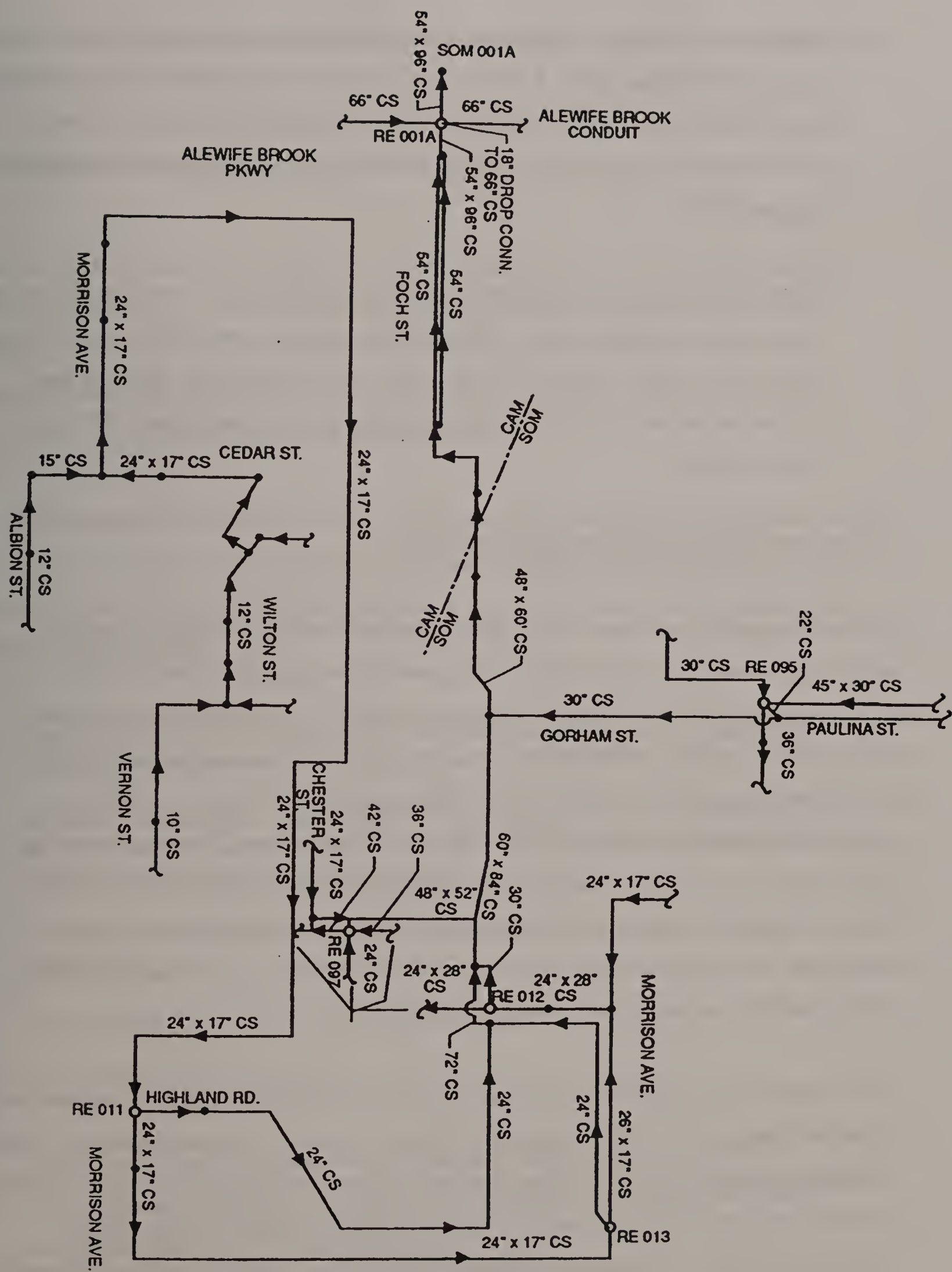


FIGURE 3-9. SCHEMATIC OF OUTFALL SOM001A

RE095. This regulator is a high-outlet type, located at the intersection of Holland and Paulina Streets (Figure 3-9). A 36-in. CS conveys flow from RE095 to the Cambridge Branch Sewer system. When the depth of flow in the regulator exceeds 4.3 feet, overflow is diverted to a 24-inch conduit tributary to the Tannery Brook Drain and regulator RE01A.

RE097. This regulator is a side-outlet weir type, located at the intersection of Elm and Day Streets Road (Figure 3-9). A 42-in. CS conveys flow from RE097 to the Cambridge Branch Sewer system. When the depth of flow in the regulator exceeds 1.85 feet, overflow is diverted to a 30-inch conduit tributary to the Tannery Brook Drain and regulator RE01A.

DESCRIPTION OF SWMM MODEL UPDATE

This section presents a summary of activities conducted to update the MWRA's existing system-wide model for use in evaluating CSO control alternatives for Alewife Brook. A collection system model of the CSO communities and MWRA interceptors was previously developed as part of the MWRA's System Master Planning activities, using the USEPA Storm Water Management Model (SWMM). This planning-level model was calibrated using flow data collected during 1992 and 1993, and was based largely on record drawings and community sewer maps. The portion of the model covering the city of Cambridge was based on information contained in the 1992 version of the city of Cambridge 100-scale sewer maps. These maps showed streets, locations of manholes, invert elevations, sanitary sewers, combined sewers, and storm drains.

As previously noted, information developed by the city of Cambridge and its consultants during preliminary design of the CAM002 and CAM004 sewer separation projects indicated a number of differences between the 100-scale sewer maps and actual conditions in the field. Accordingly, the Alewife portion of the system-wide SWMM model was updated to reflect the new information provided. The activities described below include: review of existing information; additional flow monitoring and field inspections; and revision and re-calibration of the model. A

schematic of the updated model for the Alewife Brook area is presented in Figure 3-10 (in map pocket).

Review Of Existing Information

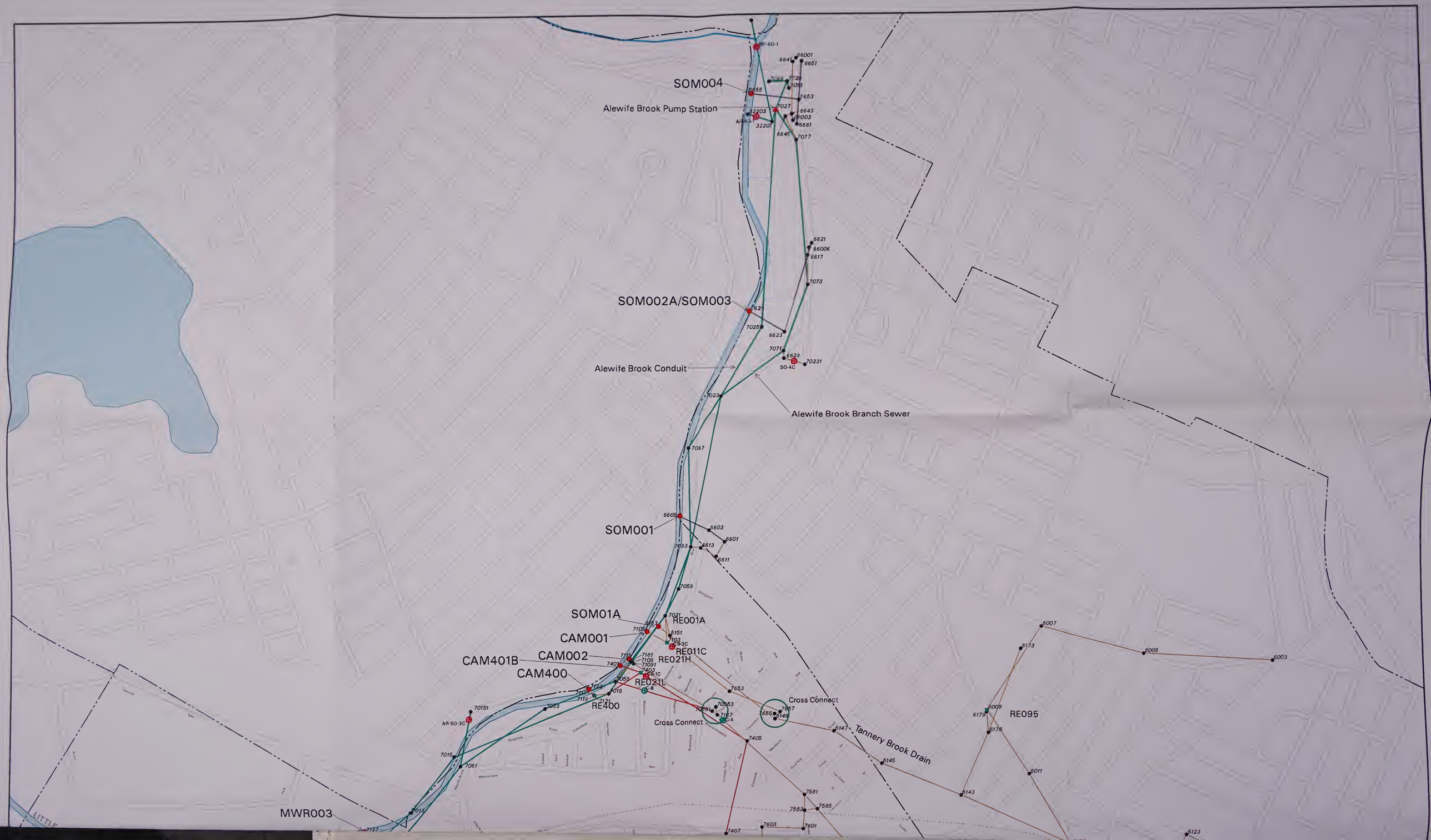
In the fall of 1999, information from the city of Cambridge, the city of Somerville, and the MWRA was reviewed to determine how the MWRA collection system model should be configured to best represent the existing conditions in the Alewife Brook System. This information was originally presented in the MWRA's August 2002 *Draft Report on Re-evaluation of CSO Control Alternatives for Alewife Brook.*

City of Cambridge Information Sources. Various meetings were held with representatives of the city of Cambridge that contributed to a better understanding of the collection system in Cambridge. Specific sources of information that were reviewed and/or used to support the modeling effort included:

- Preliminary design documents and drainage sub-models prepared by the city of Cambridge and its consultants for the CAM002 and CAM004 separation projects,
- Construction drawings of the Orchard Street Neighborhood Sewer Separation and Improvements Project Contract 3 and Fresh Pond Parkway Sewer Separation and Surface Enhancement Project Contract 2B,
- The February 1999 Bellis Circle Stormwater Management Conceptual Design Report, and
- GIS mapping from the city of Cambridge web site.

Each of these items is discussed below.

Preliminary Design Documents and Drainage Sub-models. The city of Cambridge and its consultants produced two preliminary design reports related to the Alewife Brook sewer separation project:


SOM004
Alewife Brook Pump Station
SOM002A/SOM003
Alewife Brook Conduit
Alewife Brook Branch Sewer
SOM001
SOM01A
RE001A
CAM001
RE011C
CAM002
RE021H
CAM401B
CAM400
RE021L
RE400
Cross Connect
Cross Connect
Tannery Brook Drain
RE095
MWR003

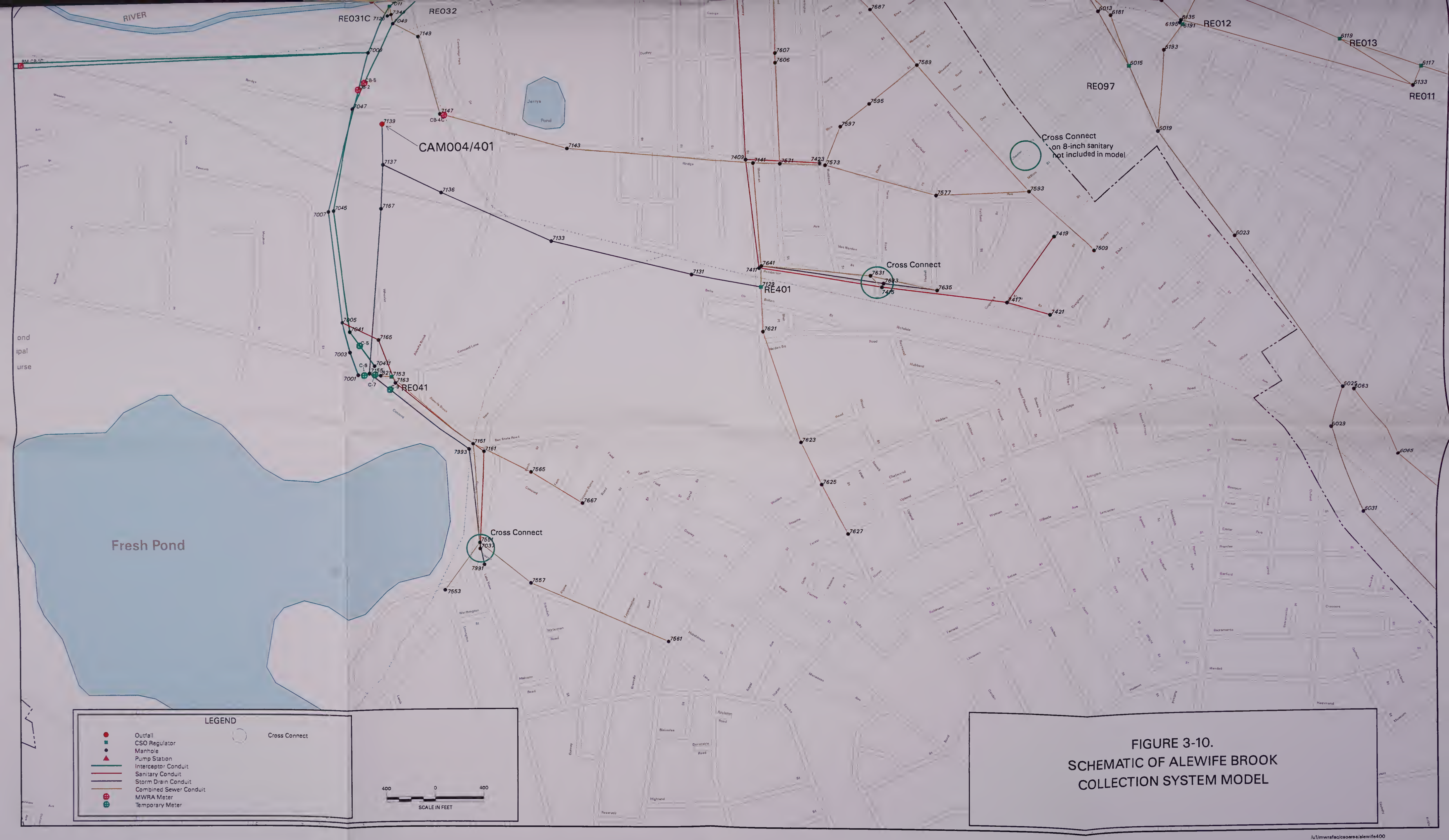


FIGURE 3-10.
SCHEMATIC OF ALEWIFE BROOK
COLLECTION SYSTEM MODEL

/u1/mwrafac/csoarea/alewife400

- The *Interim Preliminary Design Report on the Separation of Combined Sewers, Construction of New Storm Drains and Sanitary Sewers, Floatables Control and Other Improvements in the CAM 001/002/004/400/401 Areas and Floatables Control City-Wide*, dated February 27, 1998 (IPDR), and

- The *Supplement to the Preliminary Design Report for Sewer Separation in CAM002 and CAM004 and Floatables Control City Wide*, dated November 1998 (SPDR).

The IPDR and SPDR were reviewed for information that would support updating of the existing SWMM model for the Alewife area, however neither document contained information in sufficient detail to support specific revisions to the existing SWMM model. Within the SPDR, two sub-models of the drainage systems in the CAM002 and CAM004 areas were discussed. The sub-models were used in the SPDR to assess the hydraulic capacity of the existing combined sewer system, and to size new pipes to provide improved drainage capacity following sewer separation. Model results indicating the extent of predicted surcharging under existing conditions and following the proposed sewer separation were presented, and the conclusion was drawn that the existing wet weather conveyance capacity was limited to a 1-year to 2-year storm event.

The CAM002 and CAM004 sub-models were obtained from SEA Consultants, Inc. for use in expanding the MWRA collection system model. The CAM002 sub-model covered the area along Massachusetts Avenue from the CAM002 regulator to Porter Square, and included the side streets that contributed to the CAM002 outfall. The CAM004 sub-model began in the vicinity of regulator RE041, and extended upstream along Fresh Pond Parkway, with major branches extending up Concord Avenue, Vassal Lane, Lakeview and Lexington Avenue.

Since the CAM002 and CAM004 sub-models extended further into the upstream reaches of the tributary areas than the MWRA's existing system-wide model, it was initially thought that the two sub-models would be inserted into the system-wide model as a means of updating the system-wide model. However, because of

differences in numbering convention and elevation datum, and the fact that modeling every pipe in every street would not significantly improve the accuracy of the model, it was determined that a more limited number of individual nodes and conduits would be added to the existing system-wide model. The Cambridge sub-models were used as a source of information for expanding the system-wide model.

The sub-models were, however, assessed individually, as an independent check of the conclusions drawn in the SPDR. A calibration check of the sub-models was performed using a storm that occurred on November 3, 1999. This storm had a total accumulation of 0.56 inches, with a peak intensity of 0.14 inches/hour (the flow metering program conducted to support model calibration is presented in more detail below). Based on the calibration check, minor changes were incorporated into the submodels, but these changes did not affect results obtained by applying the model for a 10-year design storm.

A sub-model for the CAM401 area was also received from the city of Cambridge. Two versions of this sub-model were received. One version included most of the pipes in the CAM401 subcatchment, while the other focussed on the Bellis Circle area. The Bellis Circle version utilized a different datum. Wet weather flows for this model were developed using the Soil Conservation Service methodology, as opposed to using the SWMM RUNOFF model. As with the CAM002 and CAM004 sub-models, it was decided to use the CAM401 sub-model as a source of information as opposed to incorporating it directly into MWRA collection system model.

Orchard Street Neighborhood Sewer Separation and Improvements Project Contract 3. Contract drawings for sewer separation work conducted in the Orchard Street area were provided by the city of Cambridge. As described by the city, the work in the Orchard Street area has been completed, with the new pipes connected back to the existing Massachusetts Avenue CS.

Fresh Pond Parkway Sewer Separation and Surface Enhancement Project Contract 2A/2B. Contract drawings for the separation work along Fresh Pond Parkway were reviewed. The piping configuration presented in the drawings was represented in the model for all alternatives that included sewer separation of the upstream CAM004 area.

Bellis Circle Storm Water Management Conceptual Design Report. This report described two phases of proposed stormwater management alternatives to alleviate flooding in the Sherman Street combined sewer in the vicinity of Bellis Circle. Phase I consisted of construction of a stormwater detention tank, berms and vortex flow regulators to control stormwater flow into the Sherman Street combined sewer. Phase II presented alternatives for retaining or rerouting stormwater from areas beyond the immediate vicinity of Bellis Circle. At the time that the model was being updated, the Phase I work had not been implemented. For this reason, the "existing conditions" model runs did not include the Bellis Circle work. The Phase I work is currently under construction, so all other CSO consolidation or partial separation model runs included implementation of the Phase I alternatives. The impact of the Phase I alternatives was approximated by reducing the stormwater area tributary to the Sherman Street combined sewer.

GIS Mapping From The City Of Cambridge Web Site. The city of Cambridge has developed an extensive geographic information system (GIS) map library encompassing a wide variety of data coverages, including sewer and drain layouts, land-use types, and utilities. Individual coverage files could be obtained from the city, while pre-made maps could be downloaded from their website in a "pdf" format, which is not easily edited. The maps used in this report were downloaded from the website.

City of Cambridge Sewer and Drain Atlas (June 1999). This atlas includes GIS coverages of sewer and drain piping based on a 1993 update of the city's 100-scale Sewer and Drain System maps. It is understood that the information contained in

this atlas had not necessarily been updated to reflect the findings of the field investigations conducted during preliminary design of the CAM002 and CAM004 separation projects. However, the information was useful in understanding general system configuration.

Atlas of Cambridge (April 1999). This atlas delineated major land-use types and was used as the base map for preliminary layouts of consolidation/storage alternatives.

City of Somerville Information Sources. Sources of information on the city of Somerville combined sewer system in the Alewife Brook area included MWRA reports on the status of sewer separation and system optimization plan (SOP) implementation, and personal communications with a representative of the city of Somerville DPW. Based on information previously provided to the MWRA by the city, all of the CSO discharges to Alewife Brook have been eliminated with the exception of outfall SOM01A, at the downstream end of the Tannery Brook Drain. The Tannery Brook Drain currently discharges to the ABC via an 18-inch drop connection. Downstream of the drop connection, the invert of the drain rises to a point 4.3 feet above the invert at the drop connection, prior to discharge to Alewife Brook. The recommended System Optimization Plan (SOP) for SOM01A was to install a 1-foot weir across the high point of the drain downstream of the drop connection, and to increase the diameter of the drop connection to 30 inches. The current status of SOP implementation is that the weir has been installed, but the diameter of the drop connection has not been increased. As discussed above, five upstream regulators discharge CSO to the Tannery Brook Drain, and a number of separate storm drains are also tributary. The city is currently looking into the feasibility of controlling miscellaneous dry weather sanitary discharges to the Tannery Brook Drain, and tentatively plans to assess the feasibility of separating the upstream regulators, closing off the drop connection to the ABC, and turning the Tannery Brook Drain into a separate storm drain.

MWRA Information Sources. The record drawings for the ABC, ABBS, and Alewife Brook Pumping Station (ABPS), were reviewed, as appropriate, to check the connectivity and configuration of the MWRA collection system model. Because of the key function of the ABPS as the downstream hydraulic control point for the Alewife Brook interceptors, a detailed review of pumping capacity at the facility was conducted.

Alewife Brook Pumping Station. As part of the evaluation of existing system conditions, M&E met with ABPS staff to better understand station operation and to collect information to update the modeled configuration of the ABPS.

The ABPS currently features three constant-speed, 26-mgd pumps and one constant-speed, 12-mgd pump. The 26-mgd pumps discharge to the North Metropolitan Relief Sewer (NMRS), and the 12-mgd pump discharges to the North Metropolitan Trunk Sewer (NMTS). Currently, the ABPS can be operated in a manual (MANUAL) or in an automatic (AUTO) mode. In the AUTO mode, one of the three 26 mgd pumps is designated as the primary pump and will automatically activate when the wetwell water surface reaches el. 100.00 (all elevations in MDC datum). The primary pump will stay on until the wet well level drops to el. 95.00. If the influent flow is too much for the one pump to handle, the two additional 26 mgd pumps can be activated to help control the increasing water level. Pump Nos. 2 and 3 will activate when the water surface reaches el. 101.50 and el. 102.00, respectively. According to the chief operator, the average daily flow is approximately 8 mgd, with a peak pumping capacity near 75 mgd. A review of circular charts of pump flow rate confirmed this peak capacity.

In most cases, operators run the station in the AUTO mode, but may run the fourth 12 mgd pump manually at different times to keep the increasing storm flow under control. In some cases, the operators may run one of the 26 mgd pumps and the 12 mgd pump during the "first flush" of the storm in hopes that the two in parallel can keep up with the storm surge, making it unnecessary to run additional 26 mgd pumps. In another case, the operators may run the 12 mgd pump just before the

first flush of the storm to keep the wetwell elevation at or near 95.00, allowing for maximum storage capacity in hopes of catching the entire storm volume. In the MANUAL mode, operation is based primarily on operator experience.

Circular charts of pump flow rate were reviewed for 22 storm events between November 1997 and November 1999. Rainfall data from Logan Airport were obtained for these storms, and relationships between rainfall and peak pumping rate were investigated. To better gauge the storm response under typical station operation in AUTO mode, two regressions were run on plots of rainfall versus maximum pumping rate: maximum recorded pump rate versus total rainfall (Figure 3-11) and maximum recorded pump rate versus rainfall intensities (Figure 3-12).

As indicated in Figures 3-11 and 3-12, the relationship between peak pumping rate and rainfall intensity had a much stronger statistical fit ($R^2 = 0.52$), than the relationship between peak pumping rate and total rainfall depth ($R^2 = 0.24$). This outcome is not surprising considering that a storm of one inch of rain over 2 hours would have a greater impact on pumping station operation than if the same rainfall volume came over a longer period of time. Figure 3-12 also suggests that during normal operation of the station, storm intensities of greater than 0.30 inches per hour are likely to cause the pumping station to pump at its maximum rate of approximately 75 mgd. When the pumping station is operating at maximum capacity, it is likely that overflows would be occurring at upstream CSOs due to the quantity of flow from the local systems and/or surcharging in the interceptor.

In both regressions, the data point for the November 3, 1999 storm used for model calibration fell reasonably close to the regression line, indicating that the pumping station was likely operating in AUTO mode, following the prescribed operating rules, during the calibration storm.

FIGURE 3-11. PEAK FLOW vs. RAINFALL DEPTH REGRESSION AT ALEWIFE BROOK PUMPING STATION

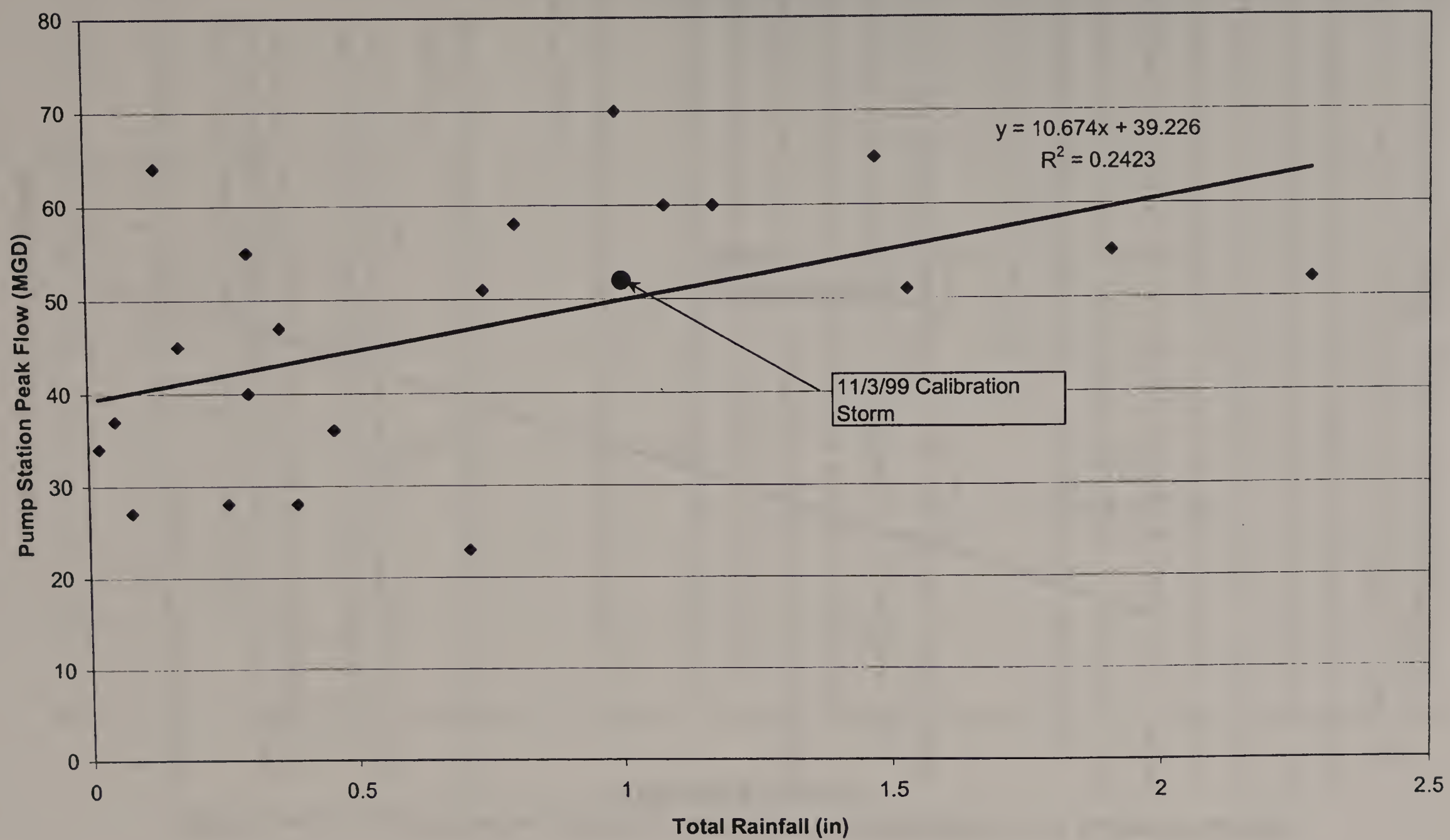


FIGURE 3-12. PEAK FLOW vs. RAINFALL INTENSITY REGRESSSION AT ALEWIFE BROOK PUMPING STATION

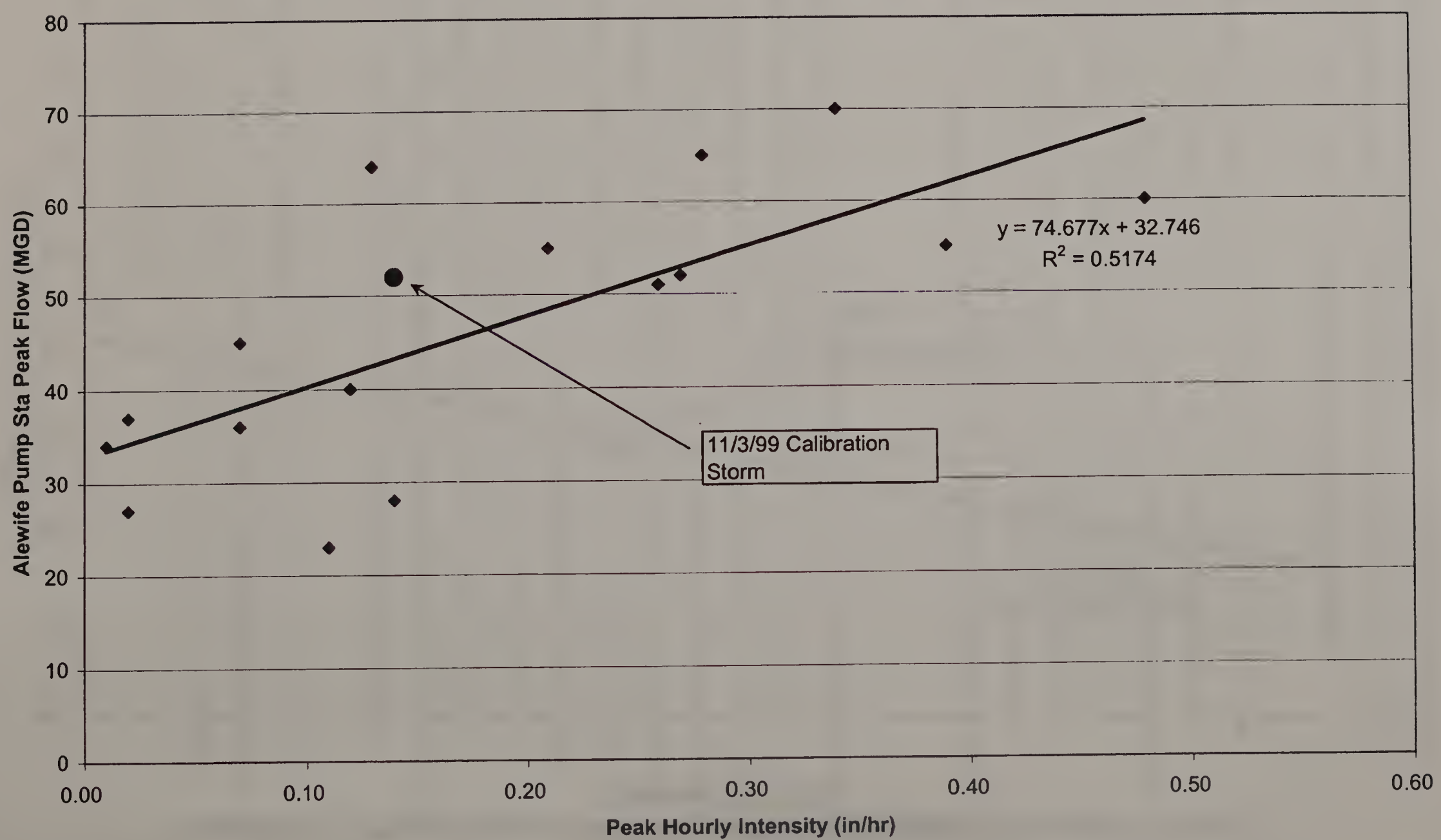


Figure 3-13 is a plot of flow readings taken from the flow data recorder and estimates of corresponding wet well elevations for the November 3rd storm. The flow data recorder did not document exact elevations and therefore, points used in creation of the figure were arrived at by comparing the water levels recorded on the operator log sheets to the position of the line on the data recorder. Upon inspection of the operating data for November 3rd, it is apparent that only one of the 26 mgd pumps cycled on and off, except for a brief period around 4:00 am when a second 26 mgd pump turned on to help with the rising wet well level. Also plotted was the wet well elevation, which seemed to vary as expected with pumps turning on at elevation 101.00 and off near elevation 95.00.

Another important operational consideration at the ABPS is how often the station has to cut back on the pumping rate due to downstream flow limitations. This condition can be observed at the station when the water level in the effluent chamber approaches the ground level. When this condition occurs, the pumping rate has to be manually throttled back. According to the plant operators, downstream capacity restricts the pumping capacity about twice per year.

Based on the available information, the Alewife Brook Pumping Station was modeled as follows:

- Three 20 mgd capacity pumps with start elevations of 99.5. 100, and 100.5, respectively.
- One 13 mgd capacity pump that runs constantly at 4 mgd for dry weather flow, increasing to 13 mgd on upstream water surface elevation of 104.
- The 20 mgd pumps are SWMM Type 3, with flow rate variable based on suction/discharge differential water surface; the 13 mgd pump is SWMM Type 2, with flow rate based on upstream water surface.

A discussion of the feasibility of increasing the capacity of ABPS is presented in Chapter Five.

FIGURE 3-13. ALEWIFE BROOK PUMPING STATION WET WELL ELEVATIONS FOR NOVEMBER 3, 1999 STORM

Flow Monitoring And Field Inspection Activities

Flow monitoring and field inspection activities were conducted to support updating the configuration of the SWMM model, and re-calibration of the model. These activities are described below.

Flow Monitoring. For model calibration, stormwater and sanitary flows were measured with six temporary meters and ten MWRA permanent meters in the Alewife Brook sewer system. The six temporary meters were installed in the project area from October 15, 1999 until November 30, 1999. Meter locations are noted in Figure 3-10. Table 3-1 presents a summary of the flow meter locations and conduit characteristics.

Rain Data. Rain gauge data was collected from a site atop the Medford City Garage on James Street. The rain gauge was installed at the same time as the temporary meters and was regularly checked by the Utility Pipeline field crew. Table 3-2 provides a summary of the rain events recorded at the Medford City Garage. A total of 14 rain events occurred during the October 15 to November 30, 1999 monitoring period.

Temporary flow meter locations. Six temporary flow meters were installed and maintained by Utility Pipeline Services of Auburn, New Hampshire. M&E developed meter locations with input from the MWRA and the City of Cambridge. The six meter locations, and the intent of each meter, are summarized as follows:

- **Meter C-4, on the 41-inch Massachusetts Avenue combined sewer.** This meter was placed at the intersection of Massachusetts Avenue and Churchill Street. The intent of this meter was to measure the combined sewer flow from the CAM002 area upstream of the CAM002 regulator.

- **Meter C-5, on the 18-inch ABBS downstream of regulator RE-041.** This meter was placed in a manhole on the ABBS behind the Ground Round near the Concord Avenue rotary. Meter C-5 measured the sanitary flow from the CAM004 area into the ABBS.

TABLE 3-1 SUMMARY OF THE FLOW METER LOCATIONS AND CHARACTERISTICS

METER NAME	CITY/ OUTFALL	METER TYPE	LOCATION	DESCRIPTION
MWRA METERS (total 10)				
AR-SO-1	Arlington	Flow	Interceptor	Lexington Branch Sewer
AR-SO-3C	Arlington	Flow	Influent	Flow from Arlington
BM-CB-1C	Belmont	Flow	Influent	Belmont Branch Sewer
CB-1C	CAM401B	Flow	Influent	Regulator for outfall CAM401B at Mass. Ave. and Alewife Brook Parkway
CB-2	CAM004	Flow	Interceptor	Alewife Brook Conduit downstream of the RE041 regulator
CB-3C	CAM001	Flow	Influent	Foch Street
CB-4C	CAM003	Flow	Influent	Rindge Ave. Extension at the Alewife T Station
CB-5	CAM004	Flow	Interceptor	Alewife Brook Branch Sewer downstream of the RE041 regulator
MF-SO-1	Medford	Flow	Interceptor	End of Jerome Street, east of Arlington Street
SO-4C	Somerville	Flow	Influent	Somerville Community Sewer
TEMPORARY METERS (total 6)				
C-4	CAM002	Flow	Interceptor	CS, in MH on Mass. Ave. opposite City Paint, near Alewife Brook Parkway
C-5	CAM004	Flow	Influent	18" SS Alewife Brook Branch Conduit downstream of RE-041
C-6	CAM004	Flow	Interceptor	48" CS Alewife Brook Conduit downstream of RE-041
C-7	CAM004	Flow	Overflow	Outfall line downstream of RE-041
C-8	CAM002	Flow	Influent	18" dia. Sanitary line on Mass. Ave.
C-9	CAM004	Flow	Storm Drain	60" dia. SD at CAM004

TABLE 3-2 SUMMARY OF RAIN EVENTS DURING OCT. 15 - NOV. 30, 1999 PERIOD

Event No.	Date Mo Da Yr	Start Hour	Duration hours	Volume inches	Avg. Intensity in/hr	Max. Intensity in/hr	Inter-event hours	Hours Missing hours
1	10/18/1999	0	13	1.02	0.08	0.22	Undef	0
2	10/20/1999	8	12	0.66	0.06	0.16	43	0
3	10/21/1999	6	1	0.01	0.01	0.01	10	0
4	10/23/1999	3	6	0.35	0.06	0.16	44	0
5	11/3/1999	0	8	0.56	0.07	0.14	255	0
6	11/10/1999	20	8	0.37	0.05	0.1	180	0
7	11/12/1999	23	6	0.1	0.02	0.05	43	0
8	11/14/1999	16	2	0.08	0.04	0.07	35	0
9	11/15/1999	9	1	0.01	0.01	0.01	15	0
10	11/20/1999	22	2	0.12	0.06	0.06	132	0
11	11/25/1999	10	9	0.16	0.02	0.09	106	0
12	11/26/1999	1	11	0.23	0.02	0.09	6	0
13	11/26/1999	19	2	0.02	0.01	0.01	7	0
14	11/27/1999	7	6	0.46	0.08	0.2	10	0

- **Meter C-6, on the 48-inch ABC downstream of RE-041.** This meter was placed in a manhole on the ABC behind the Ground Round near the Concord Avenue rotary. This meter measured the dry weather flow from regulator RE-041 entering the Alewife Brook Conduit.

- **Meter C-7, on the outfall pipe downstream of RE-041.** This meter was placed in a manhole on the CAM004 outfall behind the Ground Round near the Concord Avenue rotary. Meter C-7 measured wet weather overflow from regulator RE-041 before the flow merged with the 60-inch drain flow on Wheeler St.

- **Meter C-8, on the 18-inch sanitary line on Massachusetts Avenue.** This meter was placed to measure flow on the 18-inch sanitary line that conveyed sanitary flow along Massachusetts Avenue between Meacham Road and Alewife Brook Parkway.

- **Meter C-9, on the 60-inch Storm Drain near regulator RE-041.** This meter measured wet weather flow from the 54-inch storm line on Fresh Pond Parkway before the flow mixed with the overflow from regulator RE-041.

MWRA Meters. Five of the MWRA meters used in calibration (AR-SO-1, AR-SO-3C, BM-CB-1C, MF-SO-1 and SO-4C) were located at flow boundaries to the Alewife Brook system (for example, the Belmont Branch Sewer, Lexington Branch Sewer, and Somerville community sewer). Since the upstream pipes are not modeled on these sewers, only flow rate data was used from each of these meters for calibration of the model boundary conditions.

The other MWRA meters listed in Table 3-1 were located on major sanitary and combined sewer influent lines to MWRA interceptors or were placed in the interceptors themselves. Both flow and depth information was used from these meters in conjunction with the temporary meters for calibration of the Cambridge sub-model. Graphs of flow data and rain gauge information for each of the meters are located in the Appendix B.

Dry Weather Flow Analysis. The flow meter data were analyzed to determine the dry weather sanitary and infiltration components and the wet weather response. The infiltration was calculated by multiplying the nighttime low flow by 0.9 during representative dry days. The dry weather period of October 30 to November 2, 1999 was selected as the representative dry period because it occurred during the middle of the

monitoring period and was preceded by dry weather on October 28-30, 1999. The sanitary flow was calculated by subtracting the infiltration from the average dry weather flow

Wet Weather Flow Analysis. The wet weather volumes were determined for each meter sub-basin. The wet weather volumes were calculated by subtracting the dry weather flow from the measured flow. Where appropriate, the wet weather flows were correlated with the rainfall using the relationship:

$$V = CA(R-d)$$

where:

V = volume of wet weather flow, ft^3

C = runoff coefficient

A = basin area, ft^2

R = rainfall depth, ft

d = depression storage, ft

For small storms in which the pervious areas do not contribute runoff, the runoff coefficient is approximately equal to the percent of directly connected impervious area.

Table 3-3 lists each of the 16 meters and presents estimates of tributary area and percent of impervious cover in these areas as well as estimates of sanitary inflow and wet weather infiltration.

Analysis of Meter C-7 Located in CAM004 Outfall. Periodic unexplained spikes in the depth readings for meter C-7 were observed during the metering period.

TABLE 3-3. CHARACTERISTICS OF FLOW METER SUBBASINS

METER	TRIBUTARY AREA ID	EXTRAN NUMBER	AREA (acre)	TRIBUTARY AREA TYPE	%IMP.	Sanitary (cfs)	Infiltration (cfs)
MWRA METERS							
AR-SO-1	32203	32203	100	Sanitary Inflow	4.4	0.7468	0.4998
AR-SO-3C	31018	70151	512.405	Sanitary Inflow	2.416	0.5703	0.7212
BM-CB-1C	31011	7203	2652.85	Sanitary Inflow	4	2.208	2.126
CB-1C	7403	7403	32.9	Sanitary Inflow	17	0.0766	0.0384
	7405	7405	20.74	Sanitary Inflow	17	0.0483	0.0242
	7407	7407	52.21	Sanitary Inflow	17	0.1215	0.0609
	7409	7409	31.23	Sanitary Inflow	17	0.0727	0.0364
	7411	7411	85.97	Sanitary Inflow	17	0.2	0.1002
	7415	7415	54.93	Sanitary Inflow	17	0.1278	0.064
	7419	7419	42.52	Sanitary Inflow	17	0.0989	0.0496
	7421	7421	41.79	Sanitary Inflow	17	0.0972	0.0487
	7423	7423	34.19	Sanitary Inflow	17	0.0796	0.0399
	TOTAL		**396.48**			**0.9226**	**0.4623**
CB-2	7163	7163	23.94	Sanitary Inflow	7	0.1044	0.0391
	7161	7161	61.79	Sanitary Inflow	7	0.2695	0.101
	7037	7037	130.71	Sanitary Inflow	7	0.5702	0.2136
	TOTAL		**216.44**			**0.9441**	**0.3537**
CB-3C	8051	7103	4.42	CS	30	0.0163	0.0123
		7653				0.012	0.0096
		7655					0.0509
	8130	7657	9.58	SD	30	0.2119	0.246
	TOTAL		**14.00**			**0.2402**	**0.3188**
CB-4C	8164	7143	52.33	CS	13.5	0.0769	0.1280
	8165	7141	7.49	CS	18	0.0110	0.0183
	8129	7577	4.52	CS	18	0.0066	0.0111
	8178	7593	10.08	CS	18	0.0148	0.0246
	8176	7597	7.87	CS	18	0.0116	0.0192
	8166	7607	4.75	CS	18	0.0070	0.0116
	8173	7641	19.33	CS	18	0.0284	0.0473
	81711	7631	40.97	CS	13.5	0.0602	0.1002
	81712	7635	20.48	CS	13.5	0.0301	0.0501
	8170	7623	17.36	CS	13.5	0.0255	0.0424
	8169	7625	50.18	CS	13.5	0.0737	0.1227
	8167	7627	14.75	CS	18	0.0217	0.0361
	8172	7129	17.51	CS	18	0.0257	0.0428
	TOTAL		**267.62**			**0.3933**	**0.6544**
CB-5	7045	7045	73.38	Sanitary Inflow	7	0.1	0.08
	7047	7047	19.62	Sanitary Inflow	7	0.028	
	TOTAL		**93.00**			**0.1280**	**0.0800**
MF-SO-1	31059	32261	119.615	Sanitary Inflow	7.472	0.1575	0.3592
SO-4C	70231	70231	64.98	Sanitary Inflow	1.82	0.2579	0.057

TABLE 3-3. CHARACTERISTICS OF FLOW METER SUBBASINS

METER	TRIBUTARY AREA ID	EXTRAN NUMBER	AREA (acre)	TRIBUTARY AREA TYPE	%IMP.	Sanitary (cfs)	Infiltration (cfs)
TEMPORTARY METERS							
C-4		7581				0.135	0.158
	8182	7585	6.26	SD	45		
	8181	7587	9.66	SD	45		
	8179	7589	8.64	SD	45		
	8180	7589	6.52	SD	45		
	8178	7593	10.08	SD	45		
	8177	7609	38.08	SD	45		
	8183	7601	11.99	SD	45		
	8184	7603	6.96	SD	45		
	TOTAL		**98.19**			**0.1350**	**0.1580**
C-5	(1)	70411	(1)	(1)	(1)	(1)	(1)
C-6	(1)	7001	(1)	(1)	(1)	(1)	(1)
C-7	8159	7155	23.82	SD	40		
C-8	70551	70551	19.65	Sanitary Inflow	5	0.0399	0.0185
C-9		7993					
	8199	7991	7.4	SD	40		
	TOTAL		**7.4**			**0.0399**	**0.0185**

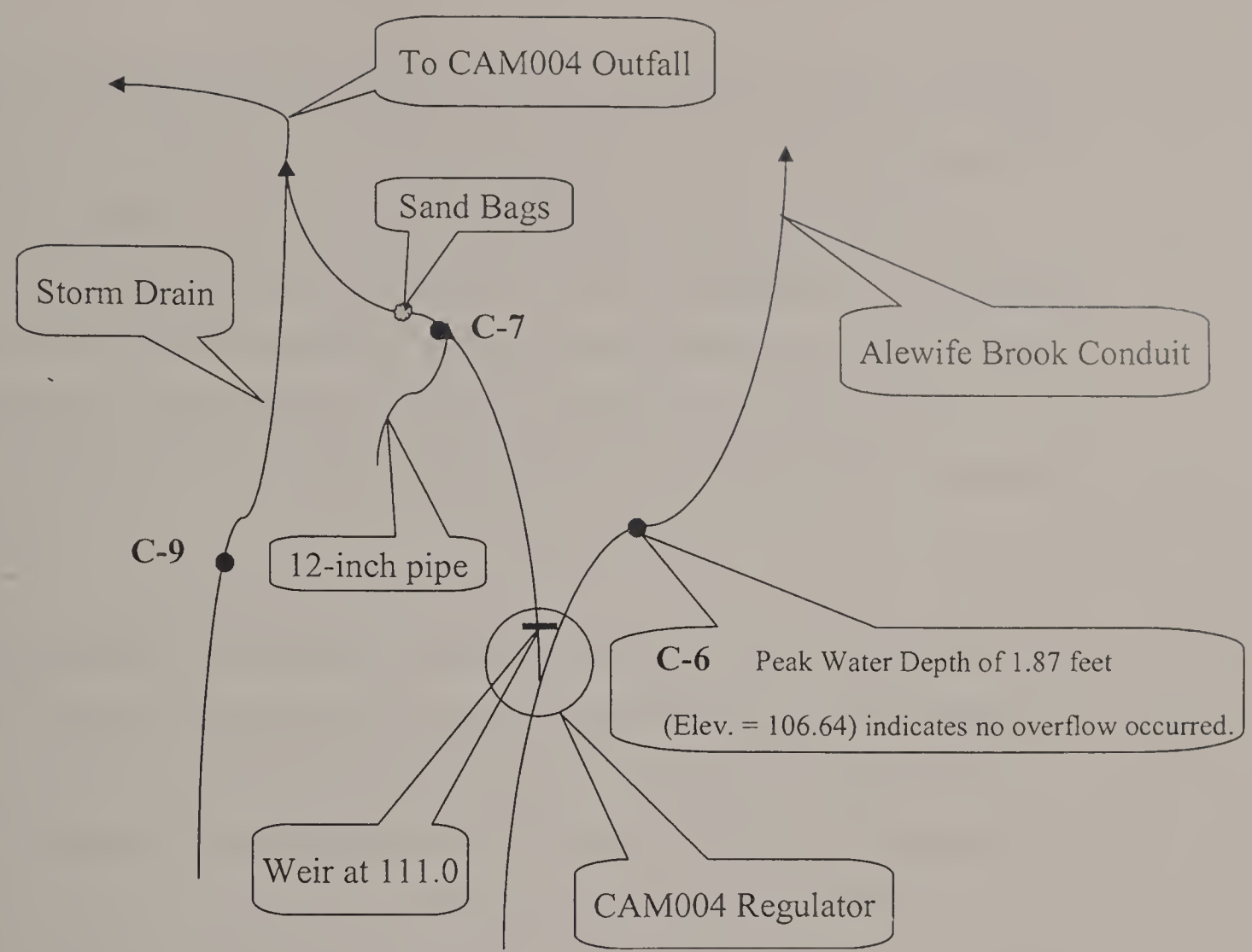
Notes: (1) Meters C-5 and C-6 were located on the MWRA interceptors. No runoff areas were directly tributary to the interceptors at the model node where the meters were located.

This response usually occurred after a rainfall event but occasionally would appear even in the absence of rain and no change in flow was recorded at the meter corresponding to the change in depth. Figure 3-14 presents a schematic showing the locations of meters C-6, C-7 and C-9 in the vicinity of the CAM004 regulator (this regulator has since been replaced by Drain Vault No. 5). A plot of measured depth versus time for the three meters for the period of November 3 to 4, 1999 is also presented. As indicated on the plot of meter data, the three meters exhibited similar depth responses to a rain event on November 3, but then meter C-7 exhibited a second depth response that was not recorded at the other two meters.

In reviewing the site inspection reports and the Contract 2B drawings, it was determined that a 12-inch diameter pipe enters the manhole where meter C-7 was located. Meter C-7 was positioned on the upstream side of the manhole and far enough back as to not be disturbed by potential turbulence created by flow discharging from the 12-inch pipe. It is possible that the 12-inch pipe drains playing fields on the south side of Fresh Pond Parkway. It was also possible that the manhole at Meter C-7 was used as a discharge location for dewatering activities associated with the Fresh Pond Parkway construction project. This possibility would explain the delayed spike observed during rain events and could be one reason why spikes were observed during dry periods.

At the same time, flow could have been restricted from leaving the manhole by sandbags that were observed to be in the downstream end of the manhole. As water pooled into the manhole from the 12-inch connection or from a dewatering discharge, the meter may have recorded an increase in depth without corresponding flow, similar to a bathtub filling.

Field Inspections. Based on review of available sewer mapping for the city of Cambridge, and on information obtained from the city during meetings, a number of locations were identified where cross connections among sanitary sewers, storm drains, and/or combined sewers could potentially exist. In order to properly account for these potential cross connections in the model, a limited number of field inspections were conducted. The intent of the inspections was to confirm whether the cross connection actually existed, and if so, to obtain information such as weir crest elevation, pipe invert



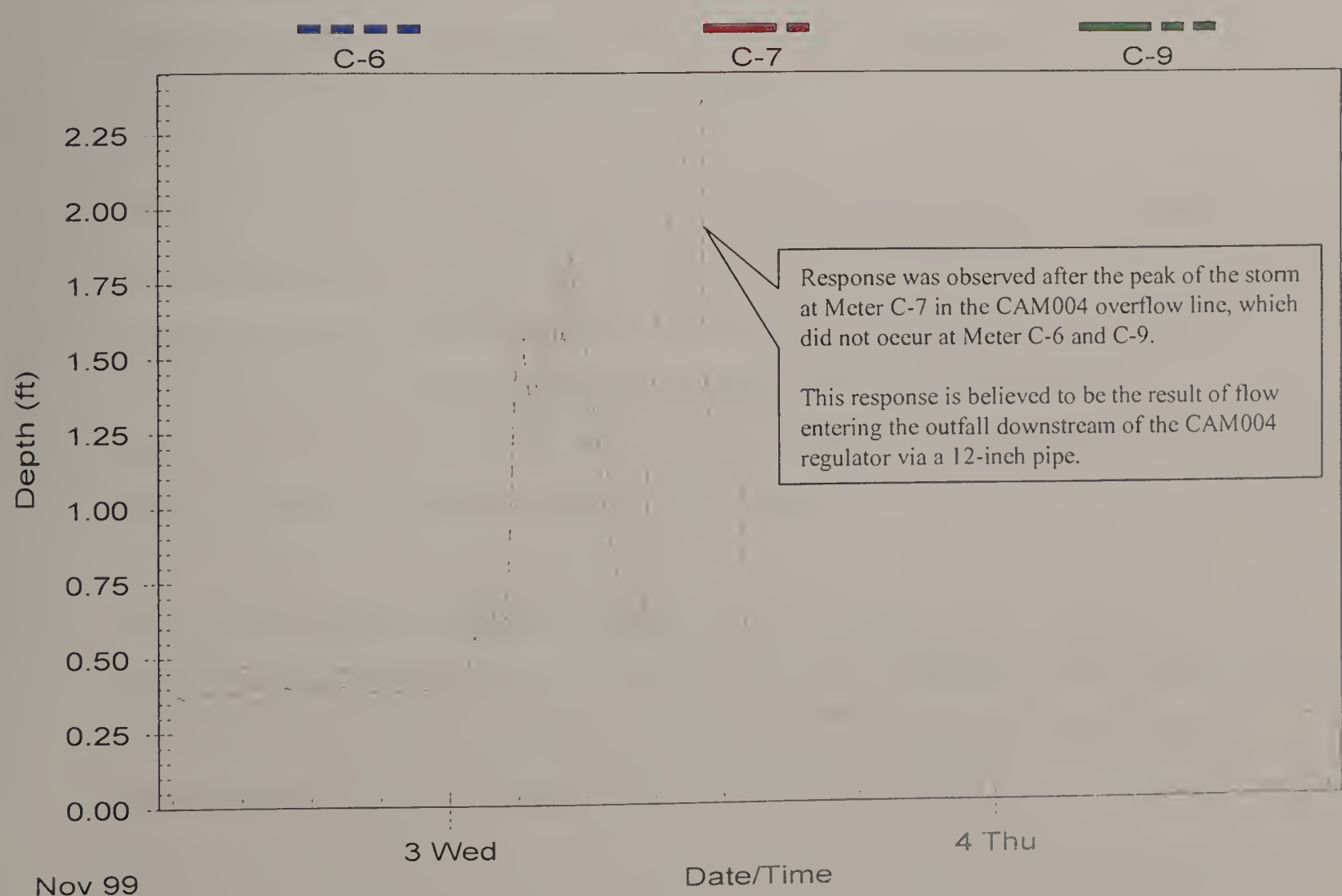


FIGURE 3-14. ANALYSIS OF METER RESPONSE AT METER C-7 LOCATED IN CAM004 OVERFLOW LINE

elevations and pipe dimensions such that the cross connection could be properly modeled. The field inspections were conducted by Utility Pipeline Services of Auburn, NH over two days (January 10-11, 2000), and were observed by M&E staff. The locations of the identified cross-connections are shown in Figure 3-10 and the locations that were inspected are summarized in Table 3-4. Descriptions of the locations inspected are presented below, and sketches and pictures from each of the inspection locations are contained in the Appendix C. It would be helpful to refer to the sketches in the Appendix while reading the descriptions below.

Clarendon Avenue and Tannery Brook Drain. The Tannery Brook Drain conveys combined sewage from Somerville to outfall SOM01A on the Alewife Brook. In order to reach the Alewife Brook, the Tannery Brook Drain passes through a portion of Cambridge in proximity to local storm drains and sanitary sewers on Clarendon Avenue. Reviewing the pipe layout in this portion of Cambridge, pipe invert elevations in four manholes on Clarendon Avenue showed the potential for cross connections. These manholes were inspected to better understand wet and dry weather flow hydraulics.

During dry weather, a portion of the flow from the Tannery Brook Drain can enter the Clarendon Avenue 15-inch sanitary sewer via a 10-inch connection. This cross-connection appears to be intended to route flow from direct sanitary connections to the Tannery Brook Drain to the interceptor system via the CAM001 sanitary system. Additionally, flow from the 12-inch storm drain on Clarendon is diverted to the 15-inch sanitary sewer via an 8-inch connection.

During wet weather, combined sewage flow in the Tannery Brook Drain can be diverted to the CAM001 sanitary system via the 10-inch connection. Flow in the 15-inch Clarendon Avenue storm drain can potentially pass over a 6-inch weir and be diverted to the Tannery Brook Drain via a 15-inch connection.

TABLE 3-4. LOCATIONS OF FIELD INSPECTIONS FOR POTENTIAL CROSS-CONNECTIONS

Location	Cross Connection Identified?	Details
Clarendon Avenue at Tannery Brook Drain	YES	Potential for dry weather flow from Tannery Brook to enter CAM001 sanitary system
Massachusetts Avenue and Churchill Street	YES	Potential for wet weather flow from combined sewer to enter Massachusetts Avenue sanitary sewer
Pemberton Street near Yerxa Road	YES	Dry weather flow from Pemberton Street combined sewer enters sanitary system
Pemberton and Sherman Streets	NO	No cross-connection; Pemberton Street storm system connects with Sherman Street combined sewer via sleeved connection through Sherman Street sanitary pipe. Sleeved connection could potentially create a hydraulic restriction
Sherman Street and Rindge Avenue	NO	No cross-connection; sanitary system is below combined system

Massachusetts Avenue and Churchill Street. The 15-inch combined sewer that runs down Churchill Street to the Massachusetts Avenue combined sewer can overflow to the 15-inch sanitary sewer on Massachusetts Avenue during wet weather events. Upstream of the connection between the Churchill Street and Massachusetts Avenue combined sewers, the Churchill Street combined sewer passes through a manhole as an open trough above the 15-inch sanitary sewer on Massachusetts Avenue. During storm events, flow can spill over the top of the

trough and into the sanitary sewer below. All dry weather flow from the Churchill Street combined sewer is channeled to the Massachusetts Avenue combined sewer.

Pemberton Street near Yerxa Road. A 12-inch sanitary sewer on Yerxa Road connects to a 25x22-inch sanitary sewer on Pemberton Street, and a parallel 31x22-inch combined sewer on Yerxa Road connects with a parallel 42x33-inch combined sewer on Pemberton Street. As the pipes are arranged, the Yerxa Road combined sewer must cross the Pemberton Street sanitary sewer to connect to the Pemberton Street combined sewer. The sewer mapping indicated the invert of the combined sewer to be at the same elevation as the sanitary sewer when the two crossed, suggesting a possible cross connection. Upon inspection of the manhole, it was learned that the combined sewer did connect with the sanitary in what appeared to be an old manhole structure that had been paved over. Most of the dry weather flow from the Yerxa Street combined sewer was diverted to the 25x22-inch sanitary sewer on Pemberton Street. Pipe inverts from the abandoned manhole showed the combined sewer to be more than two feet higher than the sanitary sewer. This difference in elevation acted as a weir, diverting combined flows to the sanitary sewer. Additionally, it was noted that upstream dry weather flow from the Pemberton Street combined sewer flowed through the cross connection into the Pemberton sanitary sewer.

Pemberton and Sherman Streets. Review of the Cambridge Sewer and Drain Atlas showed that the Pemberton Street combined sewer and storm drain intersected the Sherman Street combined sewer at the intersection of Pemberton and Sherman Streets downstream of the CAM 401 regulator. Additionally, the Pemberton Street sanitary sewer intersected the Sherman Street sanitary sewer at the same intersection. In order for the Pemberton Street combined sewer and storm drain to tie into the Sherman Street combined sewer, they must cross over the Sherman Street sanitary sewer. From invert elevation information, it appeared as if the Pemberton Street storm drain intersected the Sherman Street sanitary sewer. Upon inspection of the pipe array, the storm drain was found to be sleeved through

Mapping. The first step in refining the model required producing an accurate map of the collection system in the project area. Base mapping layers, including roads and water courses, were downloaded from MassGIS. The following components were added to the base map:

- MWRA Interceptors
- Combined Sewers
- Storm Sewers
- Sanitary Sewers
- Model nodes
- Regulators
- Meters
- Outfalls
- Pumping Stations
- Known Cross-Connections

Figure 3-10 (in map pocket) shows the interceptors, community sewers and other major hydraulic structures in the project area, which are included in the model.

Refinements to RUNOFF Model. As noted previously, the RUNOFF module of SWMM was used to simulate basin hydrology and related phenomena. This included simulation of stormwater runoff in combined sewer and stormwater catchments. The RUNOFF module was also used to simulate inflow in sanitary sewers.

Stormwater RUNOFF. The stormwater drainage areas used in the RUNOFF module of SWMM were refined to more accurately represent drainage patterns and land uses in the project area. The drainage areas originally used for facilities planning were subdivided to correspond with the increased detail in EXTRAN.

Figure 3-15 shows the new basin delineations. There are two types of basins: combined sewer and stormwater. The characteristics of the basins are shown in Table 3-1.

Inflow. Rainfall-induced inflow is defined as the amount of extraneous flow that enters the separated sewer system and service connections during wet weather. Inflow is distinguished from runoff, which enters combined and stormwater systems during wet weather. The primary sources of inflow include, but are not limited to, roof leaders, cellar pump out, yard and area drains, foundation drains, manhole covers, cross connections from storm sewers and combined sewers, and rainfall induced groundwater infiltration. Because of the highly variable nature of inflow, the quantity of inflow cannot generally be predicted from surface features, and must be based on flow metering. The quantity of inflow for a particular basin can be calculated by subtracting the dry weather flow from the wet weather flow for a particular storm. The volumetric inflow coefficient, C, can then be estimated using the following expression:

C = Inflow Volume / (Rain Depth*Basin Area)

The volumetric inflow coefficient represents the fraction of rainfall that enters the sewer system as inflow. The approach being used to simulate inflow into areas served by separate storm sewers uses the RUNOFF block of SWMM as a synthetic inflow hydrograph generator. This differs from the more conventional use of RUNOFF to simulate overland flow and related phenomena. To simulate inflow, input parameters are suitably selected to yield flows that match inflows determined from measurements. Inflow basins were added to separated basins in Cambridge and Somerville, as indicated in Figure 3-16. The inflow coefficients used in the model were calculated based on the November 3, 1999 storm and are summarized in the Table 3-1.

2500 0 2500

SCALE IN FEET

N

FIGURE 3-15.

ALEWIFE CSO AREA

COMBINED SEWER AREA AND

SEPARATE STORMWATER AREA

FIGURE 3-16.
ALEWIFE CSO AREA
INFLOWS

2000 0 2000
SCALE IN FEET

N

Refinements to EXTRAN Model. The EXTRAN module of SWMM is used to route flows through the pipes. The following enhancements were made to the EXTRAN model to more accurately simulate flows in the Alewife Brook system.

Sanitary Sewers. In general, the model was extended to include sanitary sewers of 24-inch diameter and greater. Additional sanitary sewer lines were added at following areas:

- CAM401B – sanitary sewer system, dry weather connection to ABC and CSO outfall CAM401B;
- CAM004 – newly constructed 24-inch diameter connection from CAM004 sanitary line to ABC;
- CAM002 - 18-inch sanitary line on Massachusetts Avenue where temporary meter C-8 located.

Cross-Connections. The model was extended to included known cross-connections as discussed above. As noted previously, the general impacts of all interconnections not explicitly modeled using EXTRAN are empirically simulated using the inflow model. The following is a summary of the cross-connections simulated with EXTRAN:

- Fresh Pond Parkway near Vassal Lane: 54-inch storm drain cross-connected with a 38x42-inch combined sewer;
- Clarendon Avenue: Cross-connection between sanitary system and Tannery Brook Drain;
- Massachusetts Avenue and Churchill Street: cross-connection between 15-inch sanitary sewer and 15-inch combined sewer;
- Pemberton Street near Yerxa Road: 40x32-inch combined sewer cross-connected with 28x21-inch sanitary sewer;

Each of these cross-connections, with the exception of the cross-connection at Vassal Lane, was described in more detail in the section above on field inspections. The Vassal Lane cross-connection was not field-inspected as part of this report, because sufficient documentation already existed on the piping configuration.

Alewife Brook Pumping Station. The pumping station configuration was modified based on information obtained from the pumping station operators (refer to details presented above).

Conversion to SWMM Version 4.4. The standard USEPA SWMM code does not include a user interface for model development or viewing of results. To simplify model development and analysis of results, the PCSWMM 98 software was used. PCSWMM 98 is a pre- and post-processor for the SWMM model that allows dynamic display of pipe profiles as well as plotting time-varying flow, depth and velocity values. PCSWMM 98 also includes an interface between the SWMM model and the GIS. The GIS interface supports common map layer formats such as ARC/INFO and ArcView, and allows linkages with standard databases such as Access. PCSWMM 98 is distributed by Computational Hydraulics Int. (CHI), located in Guelph, Ontario, Canada. The system-wide SWMM model used in facilities planning was based on SWMM Version 4.3. The Alewife Brook sub-model was converted to SWMM Version 4.4 in order to allow use of more of the pre- and post-processing features of the PCSWMM modeling software. The major change required to convert from Version 4.3 to Version 4.4 involved simulation of the diurnal curve. SWMM Version 4.3 had been modified by M&E during the original facilities plan to simulate the diurnal curve within EXTRAN. SWMM Version 4.4, however, simulates the diurnal curve using the TRANSPORT block. Comparisons of SWMM Versions 4.3 and 4.4 indicated that there were no significant changes in model output as a result of converting to Version 4.4.

Model Re-Calibration

Model calibration is the process of comparing model results with measurements and resolving differences until satisfactory agreement is obtained. As noted previously, the model was originally calibrated using monitoring data collected in 1992. It was determined that the model needed to be refined and re-calibrated using more recent data. The refined SWMM model of the collection system in the project area was re-calibrated using the 1999 flow monitoring data. This section contains a description of the model re-calibration process and presents the results.

Methodology. The model calibration process entailed running the model with the measured rainfall as input and comparing measured and simulated flows and heads. The model calibration was conducted using all of the flow meters installed for the entire 6-week monitoring period. The locations of these meters are described above, and are indicated in Figure 3-10. The goal of the model calibration process was to achieve a close match between the measured and predicted flows and head. When discrepancies between measurements and calculations were observed, possible causes were investigated and the model was adjusted accordingly.

Dry Weather Flow Check. The dry weather flow used in the model was first checked using the period of October 30 to November 2, 1999 as a representative dry period. This period was selected because it occurred during the middle of the monitoring period and was preceded by dry weather on October 28-30, 1999. The sanitary flow and infiltration flows used in the model were determined during the dry weather flow analysis. This was accomplished by breaking the sewershed into meter sub-basins. Table 3-3 presents a summary of the sanitary and infiltration flows used in the model for the project area.

Wet Weather Re-Calibration. The model was then re-calibrated using data collected during the October 15 to November 30, 1999 monitoring period. To perform the model calibrations, initial model runs were made using the November 3, 1999 storm. This storm had a total depth of 0.56 inches and was preceded by several days of dry weather. Because of the relatively small size of the storm, it is unlikely that it resulted in upstream flooding which could result in a loss of water from the system. Therefore, the flows recorded at the monitoring sites are more likely to be representative of the overall basin hydrology.

Minor adjustments were made within reasonable limits to match measured flows and water levels. In general, only a few parameters were adjusted to obtain a best fit. For the RUNOFF module, the percent imperviousness and basin width were adjusted. For the EXTRAN module, the Manning's n was sometimes adjusted. As noted above, these adjustments were made within reasonable limits. In one case it was necessary to impose a restriction in the Alewife Brook Branch Sewer downstream of the connection with the Rindge Avenue sewer in order to match the hydraulic grade at meter CB-4C on Rindge Avenue and at meter CB-5 on the Alewife Brook Branch Sewer. Figure 3-17 presents a plot of flow versus depth at meter CB-5 on the Alewife Brook Branch Sewer. The plot indicates that the water level is about 0.45 feet during low flows, indicating a potential restriction exists downstream. Based on trial and error simulations, this restriction was simulated by reducing the diameter of a portion of the Alewife Brook Branch Sewer from 27 inches to 15 inches.

After the initial adjustments were made to the model, the entire 6-week monitoring period was run as one continuous simulation. This approach differs from the more common practice of calibrating to individual storms. One of the problems associated with calibrating to individual storms is that the initial soil conditions are different for each calibration storm. This results in different rates of initial infiltration, which can be difficult to determine. This problem is greatly reduced for continuous simulations since the model continually calculates the infiltration rate as a function of precipitation. As indicated in Table 3-2, the October 15 to November 30, 1999 monitoring period consisted of 14 discrete storm events.

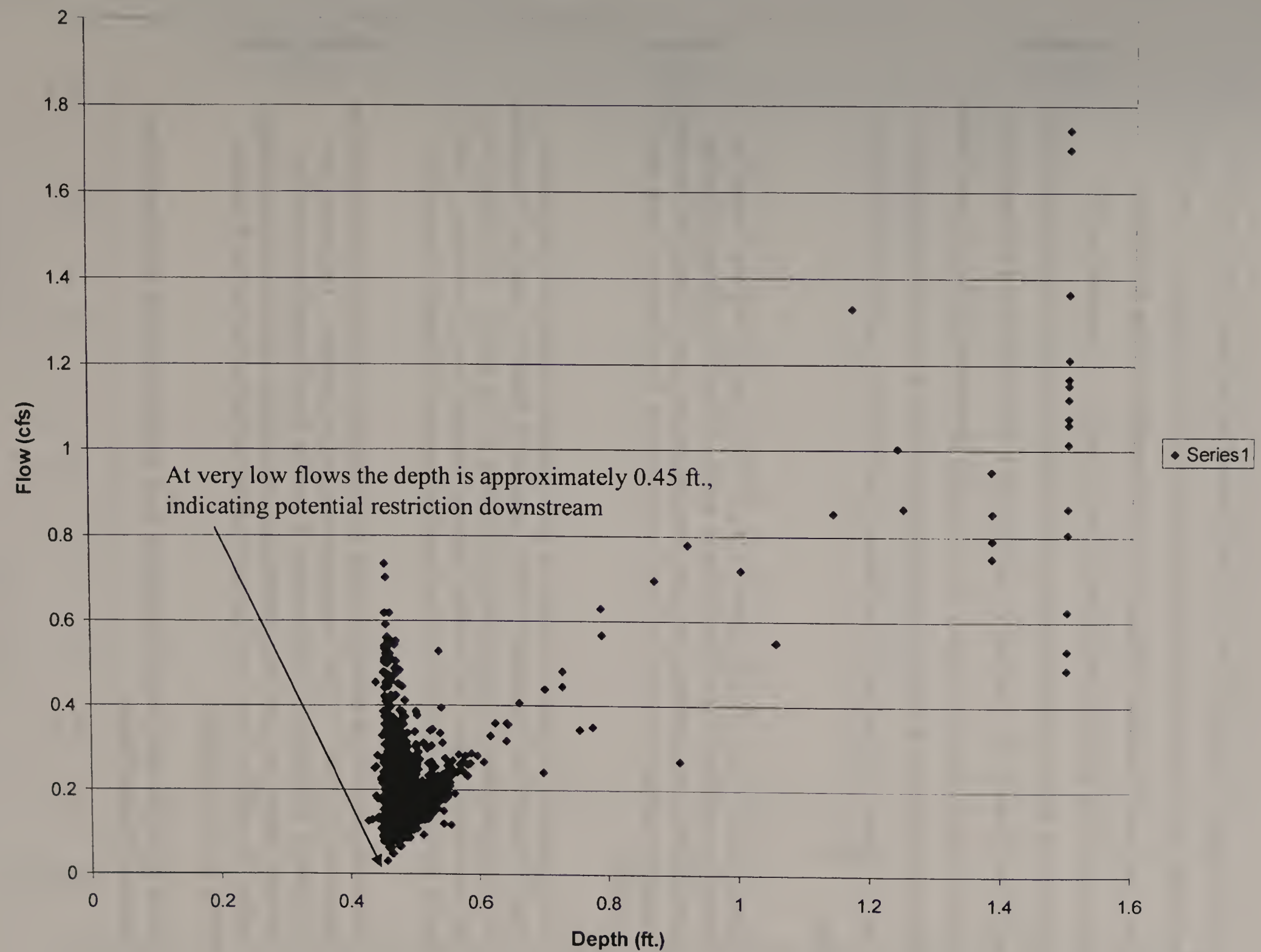


FIGURE 3-17 . PLOT OF FLOW RATE VERSUS DEPTH AT METER CB-5 INDICATING POTENTIAL RESTRICTION DOWNSTREAM

Figure 3-18 presents an example of the model calibration for the November 3 storm at temporary meter C-4, located on the influent line to the CAM002 regulator. Figure 3-19 presents an example of the model calibration for the November 3 storm at MWRA permanent meter CB-2, located on the Alewife Brook Conduit. A complete set of calibration plots for all six temporary meters and ten MWRA meters in the project area are contained in the Appendix D. The plots in the Appendix were selected to indicate five of the six storms during the monitoring period with rainfall greater than 0.25 inch; significant dry weather periods; storms at both the beginning and the end of the monitoring period; and one storm in detail. Regarding the calibration plots in the Appendix, the following is also noted:

- Meters AR-SO-1, AR-SO-3C, BM-CB-1C, MF-SO-1 and SO-4C are located at boundary conditions to the Alewife Brook system. Since the upstream pipes are not modeled on these sewers, only the flowrate data was used to calibrate the model boundary conditions. For the remainder of the meters, both flow and depth were compared.

- The top panel of the calibration plots in the Appendix covers the 18-day period from October 18 to November 4, 1999. As noted in Table 3-2, this period includes four significant storms ranging from 0.37 inches to 1.02 inches. This period also includes several days of dry weather between October 24 and November 2, 1999, and is typical of the remainder of the monitoring period through November 30.

- The lower panel of the calibration plots in the Appendix covers the 1-day period on November 27, 1999. A 0.46 inch storm occurred on this day. This storm was included in the calibration plots because it was the fourth largest storm which occurred during the monitoring period and it occurred at the end of the monitoring period. In addition, the 1-day time scale allows a detailed look at the flows and water level comparisons.

- In the plots, the meter data are colored in blue, and the simulated flows and water levels are colored in red.

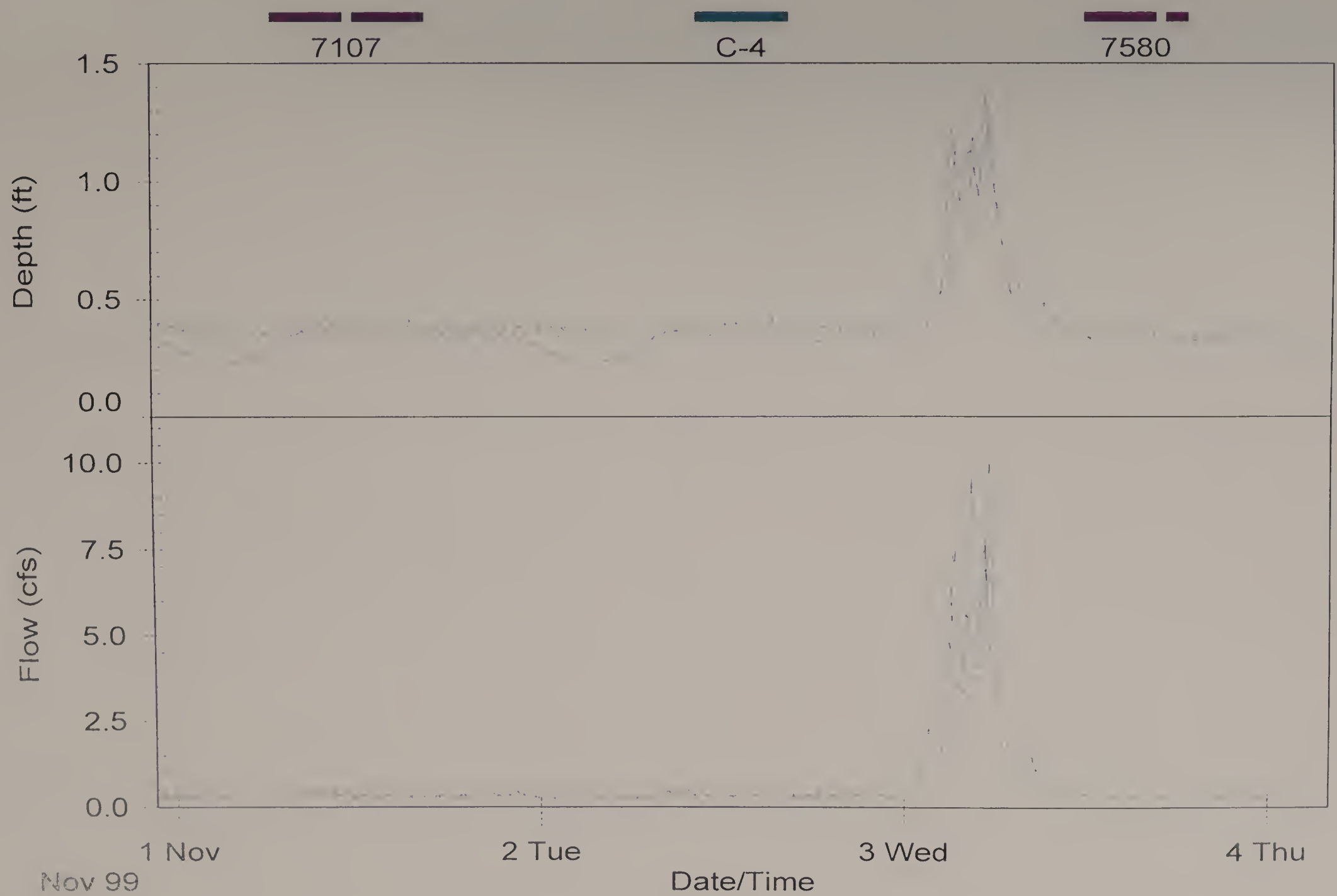


FIGURE 3-18. EXAMPLE OF MODEL CALIBRATION PLOT FOR FOR TEMPORARY METER C-4 DURING NOVEMBER 3, 1999 STORM EVENT

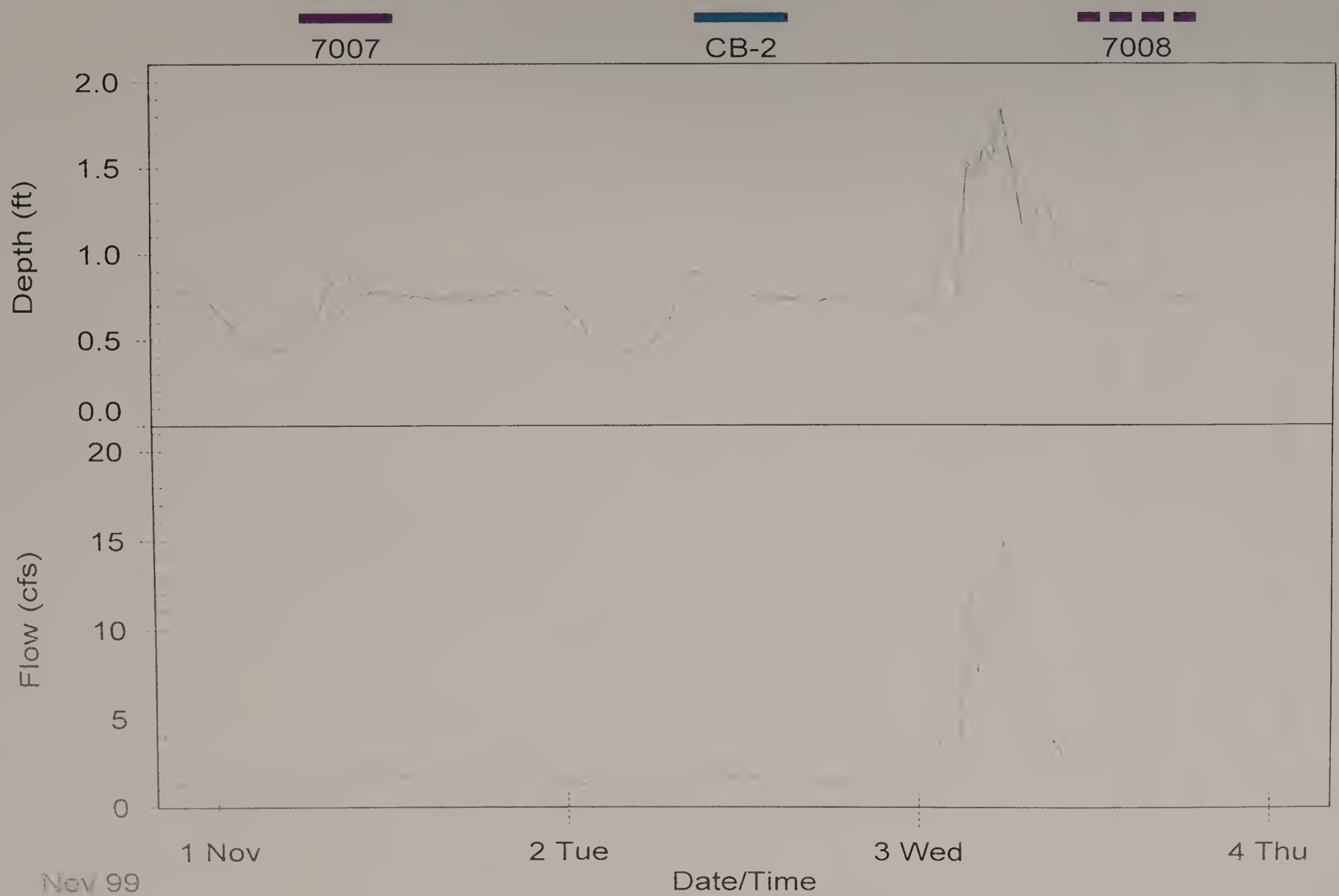


FIGURE 3-19. EXAMPLE OF MODEL CALIBRATION PLOT FOR FOR MWRA METER CB-2 DURING NOVEMBER 3, 1999 STORM EVENT

To provide a more quantitative assessment of the model calibration, the simulated and measured volumes were compared at all available locations for the complete monitoring period and the November 3, 1999 calibration storm. Regression plots of these results are also shown in Figures 3-20 and 3-21. In terms of the total measured and simulated volumes, the model is within 10 percent of the measurements. The R^2 value of the regressions is 0.99, indicating a strong correlation between measured and simulated volumes. Based on these comparisons, the model is considered to be adequately calibrated.

FIGURE 3-20. REGRESSION OF MEASURED VOLUMES VS. PREDICTED VOLUMES DURING 10/15 - 11/30/1999

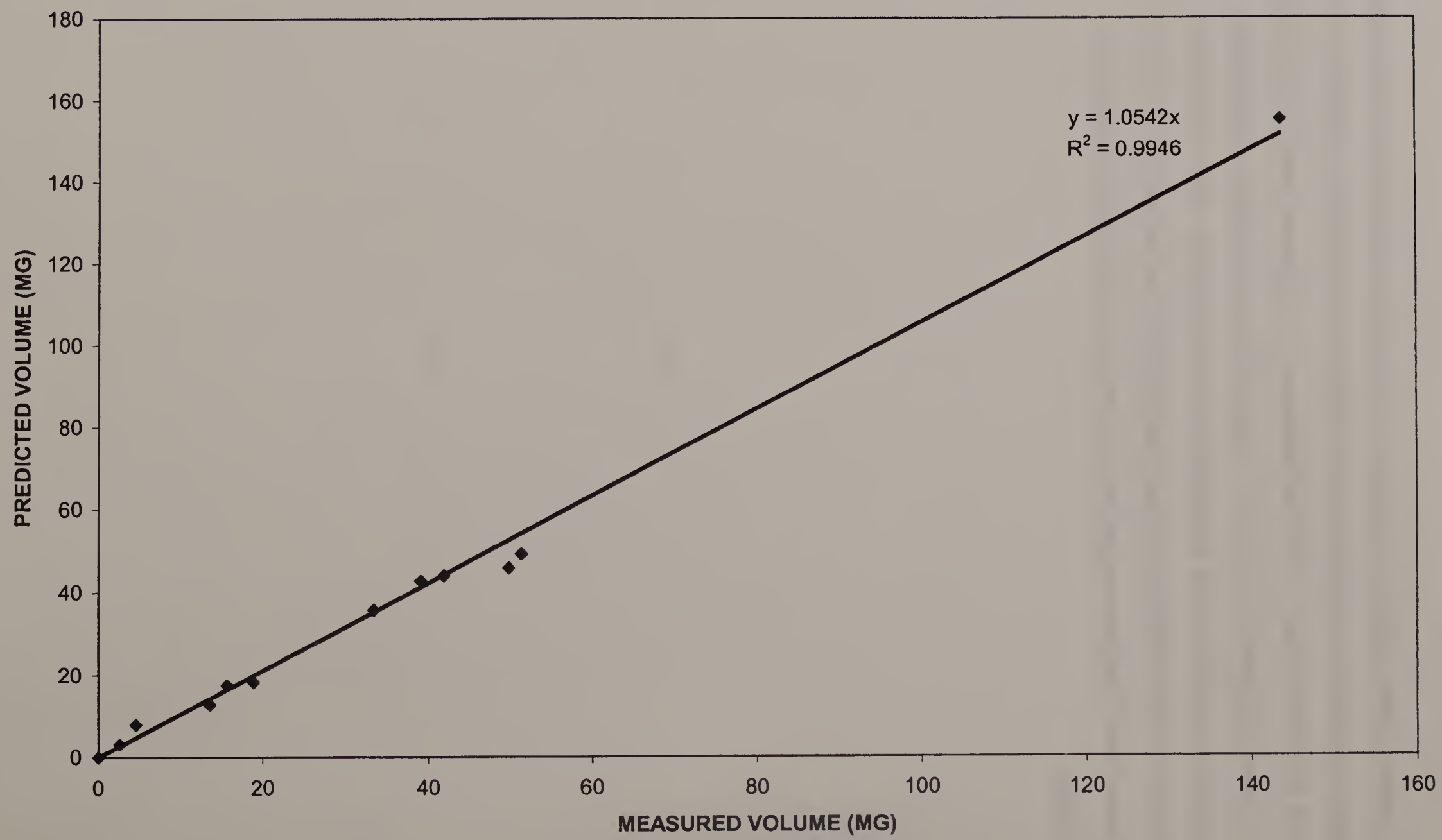


FIGURE 3-21. REGRESSION OF MEASURED VOLUMES VS. PREDICTED VOLUMES DURING 11/2 - 11/4/1999

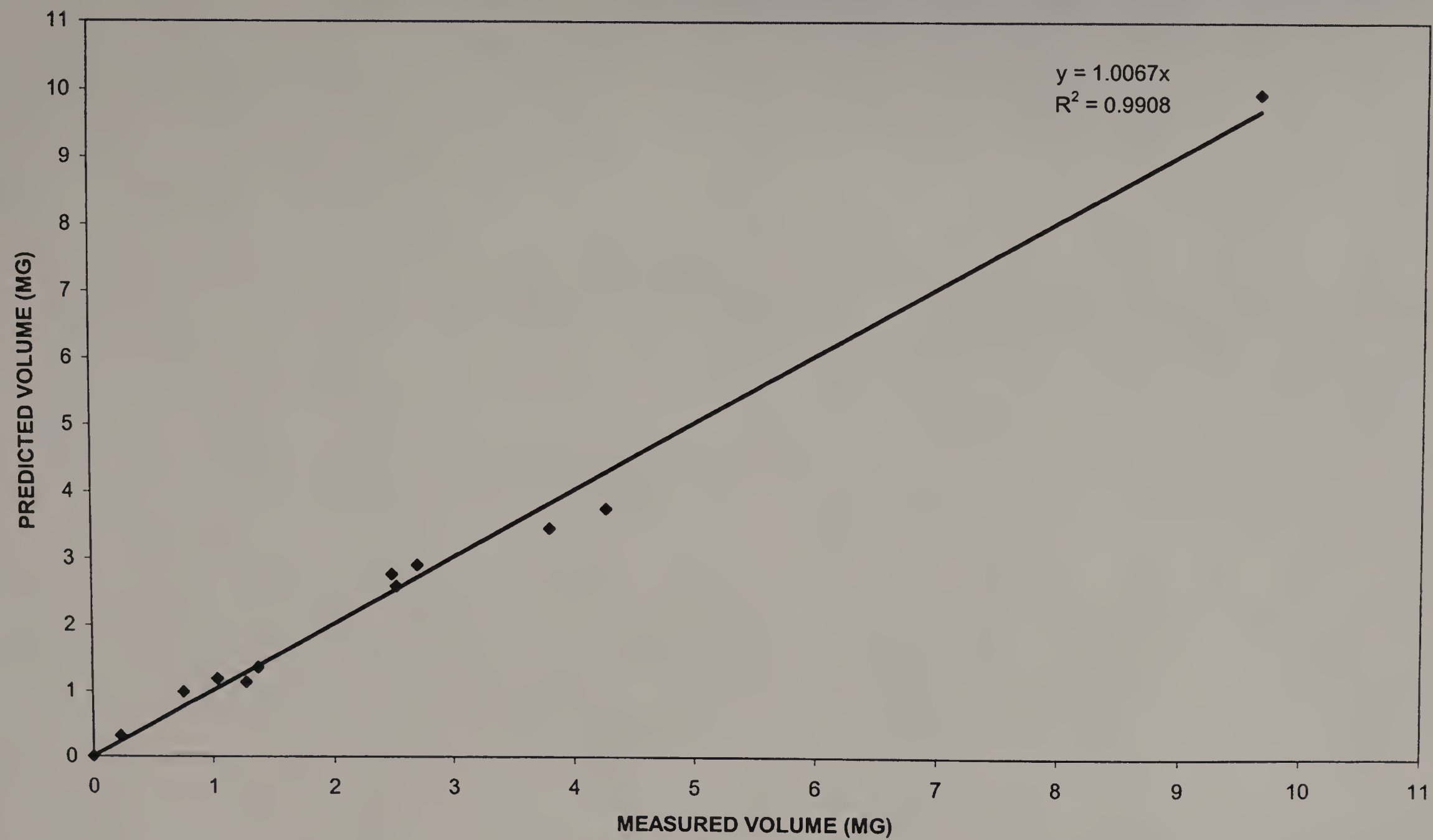


FIG 3-20-21

Section Four

CHAPTER FOUR

UPDATE OF BASELINE WATER QUALITY CONDITIONS

This chapter presents a summary of water quality sampling data collected in accordance with the conditions of the variance, followed by a description of the receiving water model used to simulate water quality conditions in Alewife Brook and the Upper Mystic River. Refinements to the calibration of the receiving water model based on recent sampling data are presented, along with the results of simulations of baseline water quality conditions.

WATER QUALITY SAMPLING PROGRAMS

This section presents the results of water quality sampling programs conducted by the MWRA and the communities of Cambridge and Somerville in accordance with the conditions of the variance. Also presented are the results of certain other sampling programs that were conducted along Alewife Brook and the Upper Mystic River during the period of the variance.

MWRA Sampling Programs

The Alewife Brook/Upper Mystic River variance included conditions that required the MWRA and the cities of Somerville and Cambridge to conduct sampling programs to refine the characterization of stormwater and CSO discharged to Alewife Brook and the Upper Mystic River and to evaluate the impacts of CSO and stormwater runoff in the two waterbodies. The three programs developed to satisfy these conditions included: receiving water monitoring (condition B(1)), stormwater sampling (condition B(2)), and CSO sampling (condition B(3)). Results from each of the studies were used to update the water quality model, discussed later in this chapter. Each of these programs is described below.

Stormwater Sampling. As set forth in condition B(2) of the Alewife Brook/Upper Mystic River variance, the MWRA and the communities of Cambridge and Somerville were required to jointly perform representative stormwater sampling semiannually for the duration of the variance at storm drain locations throughout the Alewife/Upper Mystic basin. The cities of Cambridge

and Somerville were responsible for collecting samples from stormwater outlets in their respective communities while the MWRA was responsible for collecting samples from stormwater outlets in Medford. A total of seven sampling events (Table 4-1) were conducted at 10 locations (Table 4-2) between 1999 and 2002. In addition to collecting analytical data, the MWRA and city of Cambridge also metered storm flows in the drains that were sampled. The number of sample rounds varied among all three communities, but the general approach was to collect samples during the first flush and sustained flow stages of each event. A background sample was collected by the MWRA in Medford before the storm event.

The samples were collected by teams and transported to the MWRA Deer Island Wastewater Treatment Plant (DITP) laboratory by a courier within four hours of collection. Analyses run on the stormwater samples included: biochemical oxygen demand, total suspended solids, ammonia, nitrate/nitrite, TKN, total phosphorus, and *Enterococci*, *E. coli* and fecal coliform bacteria. An arithmetic average was computed for each constituent after every event. These event-specific averages were then used to compute an overall average at the conclusion of the sampling program. The average values from the sampling program are compared with values previously used in MWRA's System Master Planning and CSO Facilities Planning activities. As noted in Table 4-3, the overall averages of the recent sampling data generally compared well to the data previously used by MWRA, with the exceptions of nitrate/nitrite and fecal coliform bacteria. Based on the findings of the stormwater sampling, the fecal coliform bacteria concentration of 30,250 colonies/100mL previously used for analysis of untreated stormwater during CSO facilities planning was reduced to 16,235 colonies/100mL.

After each event, the MWRA prepared a detailed report summarizing the flow and stormwater data collected at the 3 Medford locations. A detailed discussion of each event can be found in these reports.

CSO Sampling. In accordance with condition B(3) of the variance, the MWRA was required to collect samples from two CSOs discharging to the Alewife Brook during each of two storm events. Sampling events were conducted on November 5 and November 11, 2002.

TABLE 4-1. DATES OF STORMWATER SAMPLING EVENTS

Event	Sample Date
Fall 1999	Sampling conducted on 11/2-11/3/1999
Spring 2000	Sampling conducted on 6/6/2000
Fall 2000	Sampling conducted on 9/14/2001
Spring 2001	Sampling conducted on 12/14/2001
Fall 2001	Sampling conducted on 4/25/2002
Spring 2002	Sampling conducted on 5/2/2002
Fall 2002	Sampling conducted on 11/6/2002

TABLE 4-2. LOCATION OF SAMPLED STORM DRAINS

ID	Community	Number of Sample Rounds	Description
MED-1	Medford	5	Daly Road/Meetinghouse Brook
MED-2	Medford	5	Willis Street/Two Penny Brook
MED-3	Medford	5	Webster Street/Gravelly Brook
CAMF	Cambridge	3	Fawcett Street Outfall
CAMN	Cambridge	3	Normandy Terrance, near Mooney Street
SD07	Somerville	3	Alewife Brook, 24-inch RCP
SD08	Somerville	2	Former SOM002 CSO discharge
SD09	Somerville	2	Former SOM002A CSO discharge
SD21	Somerville	2	Mystic River, 48-inch RCP
SD26	Somerville	2	Ten Hills drainage area, former SOM007

TABLE 4-3. COMPARISON OF STORMWATER MONITORING DATA TO PREVIOUS STUDIES

Parameter	Upper Mystic/Alewife Brook Variance Stormwater Sampling Program, 1999-2002								Values used in Master Planning/CSO Facilities Planning[e]
	11/2-3/99[a]	6/6/00[a]	9/14/01[b]	12/14/01[a]	4/25/02[c]	5/2/02[a]	11/6/02[d]	Average	
Total rainfall (in.)	0.56	3.35	0.31	0.52	0.97	0.38	1.02	1.02	
BOD	26.9	9.6	19.9	8.3	18.8	9.6	12.4	15.1	20
TSS	23.5	33.0	23.9	103.7	50.7	29.3	11.5	39.4	38
Ammonia	1.11	1.00	1.10	1.00	0.72	0.64	0.18	0.82	1.1
Nitrate/Nitrite	0.88	0.56	2.03	0.85	0.91	0.83	0.33	0.91	3.7
TKN	2.90	1.64	2.61	2.06	2.41	1.60	0.89	2.02	2.6
Total Phos	0.407	0.4	0.266	0.352	0.305	0.219	0.198	0.313	0.43
Fecal Coliform	24,334	14,495	42,023	15,095	7,556	5,589	4,553	16,235	30,250
Enterococcus	11,702	18,467	96,855	29,439	7,941	6,913	7,743	25,580	N/A[f]
E. coli	14,603	10,968	10,627	7,997	4,466	3,187	2,411	7,751	N/A[f]

All values are in units of mg/l, except fecal coliform which is in #/100 ml.

In cases where the raw data were reported with a "less than" (<) qualifier, half of the reported value was used in calculation of average concentration.

(a) Values are reported as average (arithmetic mean) concentrations for sampling rounds 2,3,4, and 5 (background sampling excluded) for three monitoring locations in Medford. Data for all sampling rounds at all locations in Somerville and Cambridge were used in calculation.

(b) For 9/14/01 sampling event, data from all five rounds were used since sampling round 1 in Medford was taken during the first flush and not the background.

(c) For 4/25/02 sampling event, round 2 at location MED-2 was omitted because it sampled background conditions instead of first flush.

(d) For 11/6/02 sampling event, data from all five rounds were used since sampling round 1 in Medford was taken during the first flush and not the background.

(e) Source: *Draft System Master Plan Baseline Assessment*, June 1994.

(f) *Enterococcus* and *E. coli* bacteria were not evaluated during the previous MWRA CSO Master Planning/ CSO Facilities Planning work.

The CSOs to be sampled were selected based on two criteria: 1) the likelihood of a particular regulator to activate, given the rainfall characteristics needed to cause an overflow; and 2) access to the regulator structures. Based on these criteria, the two most suitable regulators chosen for sampling were CAM400 and SOM001A. Due to the inability to collect samples from SOM001A during the first storm event, a third location, MWR003, was added for the second storm event. Additionally, an alternate, upstream sampling location was identified for SOM001A.

Two rounds of samples were collected at each CSO during the two prescribed storm events. Round 1 was intended to occur after flow had been established in the CSO, and Round 2 was intended to occur during the sustained flow stage, after the CSO had been activating for a period of time. However, there were no CSOs observed during either event at any of the sampling locations. Samples were instead collected from the combined sewage behind the overflow weir when it became apparent that an overflow was not going to occur.

After each round of samples was collected, bottles were placed in an iced cooler and delivered by a sample runner to MWRA's DITP laboratory for analysis within four hours. At the laboratory, samples were analyzed for biochemical oxygen demand, total suspended solids, and for fecal coliform and *Enterococcus* bacteria.

The overall arithmetic mean values for each constituent obtained for the three sampling locations for both storm events along Alewife Brook are compared to the values used for untreated CSOs in Master Planning/CSO Facilities Planning in Table 4-4.

TABLE 4-4. CSO SAMPLING DATA AND COMPARSION TO DATA USED IN PREVIOUS STUDIES

Parameter	Units	Sampling Program 2002 Arithmetic Mean	Values used in Master Planning/CSO Facilities Planning
Fecal Coliform	col./100mL	601,000	538,000
BOD	mg/L	27.2	78
TSS	mg/L	27.5	140

The master planning/CSO facilities planning values were developed from various area-wide sampling programs conducted in the late 1980's and early 1990's. Although individual fecal coliform values from the two events ranged between 40,000 colonies/100mL and 1,070,000 colonies/100mL, the average fell within 20 percent of the planning value. That the average fecal coliform density was on the high side of the average is consistent with the fact that the samples were taken from the combined sewage on the upstream side of the regulator weirs during non-overflow events. The average values of BOD and TSS were substantially less than the planning values. This finding was not expected, and was not consistent with the fecal coliform data. Since the samples taken were not actually combined sewer overflow samples, only two sampling events were conducted, and the values for TSS and BOD seemed low for CSO, water quality assessments for Alewife Brook were conducted using the same average values for CSO pollutants as were used for the MWRA's System Master Planning and CSO Facilities Planning activities.

A complete analysis of the CSO sampling program can be found in the *Draft Results of the Alewife Brook Combined Sewer Overflow Monitoring Program, Fall 2002 (February, 2003).*

Water Quality Monitoring. Condition B(1) of the variance required the MWRA to collect water quality samples in the Upper Mystic River and Alewife Brook to measure water quality and assess CSO impacts on the waterbodies. The Alewife Brook/Upper Mystic monitoring program was incorporated into a larger monitoring program that the MWRA began in 1989.

The data used in this variance report was the combination of two sampling programs run concurrently in the Upper Mystic River and Alewife Brook; nutrient effects monitoring and CSO receiving water sampling. Nutrient effects samples were collected weekly January 1 through December 31 while CSO receiving water samples were collected April 1 through December 31, two consecutive days every five weeks on a rotating basis with the four other CSO water quality studies being conducted by the MWRA in North Dorchester Bay, the Charles River, the Neponset River/South Dorchester Bay, and the Inner Harbor. The schedule for sample collection

was dependant on the weather and other extenuating circumstances; however, a minimum of 20 surveys were conducted each year.

Samples were collected from 12 locations located near and distant from CSOs, with an attempt to "bracket" active CSOs. The sampling locations are indicated on Figure 4-1 (in map pocket) and are described in Table 4-5. Fecal coliform and *Enterococcus* bacteria samples were collected at each location and transported to the MWRA DITP laboratory for analysis. In addition to water samples, a water quality multiprobe (Hydrolab Datasonde 4) was used to collect temperature, salinity, dissolved oxygen, conductivity, turbidity, and pH readings at each location. The secchi depth was recorded at each location using a 10-inch secchi disk and transmissivity was measured with a WetLab Seastar tranmissometer. A number of other water quality constituents were measured at the two nutrient effects monitoring stations (066 and 167), however these data were not pertinent to this study and were therefore not included in the analysis.

On or before April 1st, the previous year's sampling data were summarized in a report that was submitted to the regulatory agencies. In developing the data analysis section of these reports, rainfall records were inspected in order to designate each sampling day as either wet or dry. By convention, three days of rainfall were associated with each sample, consisting of the sampling date plus the two previous days. Consistent with previous studies, the actual rainfall parameter used for the study was the root-mean-square (RMS) of the three days of rainfall values. This parameter places greater weight on high intensity events, which are more likely to result in CSO discharges. Thus, by using the RMS a given amount of rainfall distributed evenly over three days is given less weight than the same amount of rainfall concentrated in one of the three days.

Data were segregated into "wet" and "dry" groups, in accordance with the RMS. Values of 0.25 inch and below were used to define as dry days, while RMS values over 0.25 inch defined wet days. This definition of wet/dry days is supported by past system data for the Cambridge outfalls in the Alewife area, which show that rainfall events of 0 to 0.25 inch rarely caused CSO events.

FIGURE 4-1.
UPPER MYSTIC RIVER/ALEWIFE BROOK
WATER QUALITY MONITORING LOCATIONS

G:\Projects\MWRA\Alewife\alewife.mxd

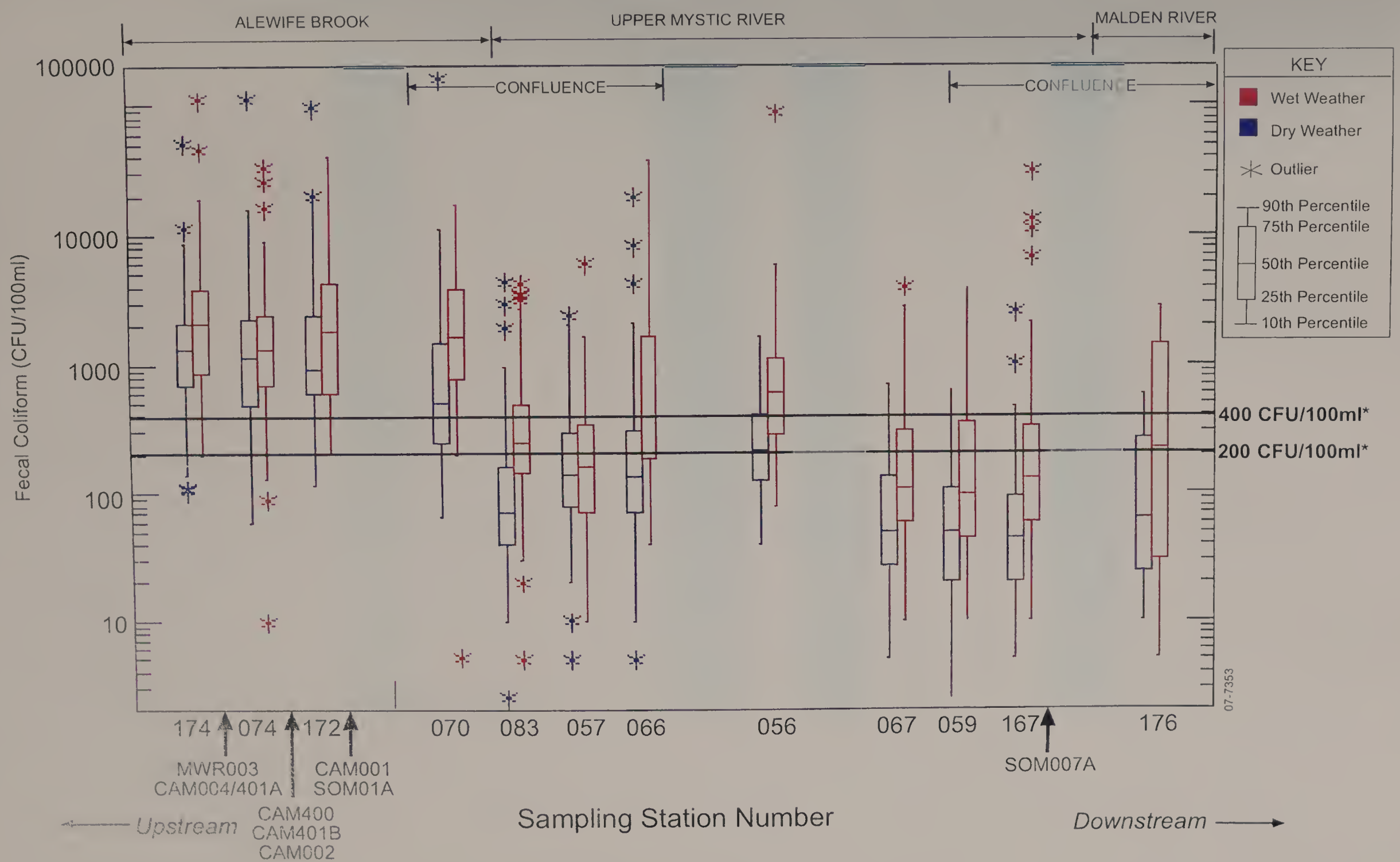
TABLE 4-5. SAMPLING LOCATIONS FOR ALEWIFE BROOK/UPPER MYSTIC RIVER CSO RECEIVING WATER MONITORING

Site No.	Description	Relation to CSOs	Latitude (N)	Longitude (W)	Depth Sampled	Comments
174	Little River, 415 ft. upstream of Route 2E off ramp to Alewife T station, from shore	Upstream of all CSOs	42° 23.85'	71° 08.71'	Surface	Sampled in 2000 - 2002.
074	Alewife Brook from bridge near off-ramp at Alewife T station, mid channel	Upstream of CAM001	42° 23.84'	71° 08.66'	Surface	Sampled in 1999 - 2002.
172	Alewife Brook from upstream side of Route 2A (Mass. Ave.) Bridge	Between CAM401B and CAM002	42° 24.08'	71° 08.17'	Surface	Sampled in 1998 - 2002
070	Alewife Brook just upstream of Mystic River confluence	Downstream of all Alewife Brook CSOs	42° 24.86'	71° 07.99'	Surface	Sampled in 1998 - 2002.
083	Mystic River just upstream of Alewife Brook confluence	No CSO influence	42° 24.92'	71° 08.09'	Surface	Sampled in 1998 - 2002.
057	Confluence of Alewife Brook and Mystic River	Downstream of all Alewife Brook CSOs combined with Mystic River flow	42° 24.92'	71° 07.99'	Surface	Sampled in 1998- 2002.
066	Mystic River just downstream of Alewife Brook confluence, from upstream side of Boston Ave. Bridge	Downstream of all Alewife Brook CSOs combined with Mystic River flow	42° 25.03'	71° 07.87'	Surface	Nutrient Effects Monitoring station; sampled 2000 – 2002.
056	Mystic River near Route 93 bridge	Well removed from CSOs	42° 24.88'	71° 06.25'	Surface	Sampled in 1998 - 2002
067	Mystic River immediately downstream of Route 28 bridge	At SOM007A (MWRA205A)	42° 23.98'	71° 05.00'	Surface and bottom	Sampled in 1999 - 2002.
059	Confluence of Mystic River and Malden River (from boat)	Downstream of SOM007A (MWRA205A)	42° 23.80'	71° 04.99'	Surface	Sampled in 1998 - 2002
176	Malden River, at Rt. 16 bridge	No CSO influence	42° 24.31'	71° 04.21'	Surface	Sampled in 2002.
167	Mystic River at Earhart Dam (from dam)	0.5 mi downstream of SOM007A	42° 23.70'	71° 04.55'	Surface and bottom	Nutrient Effects Monitoring station; sampled 1998 - 2002

Box plots of all the data collected at each receiving water sampling location over the entire variance sampling program were developed for fecal coliform (Figure 4-2), Enterococcus (Figure 4-3), and E. coli bacteria (Figure 4-3A). Each "box" in Figures 4-2 to 4-3A represents measurements from one individual sampling station. The various elements of each box represent a range of percentile values for the samples. The bottom horizontal line represents the 10th percentile, the bottom line of the box the 25th percentile, the horizontal line within box the 50th, the top line of the box the 75th, and the top horizontal line the 90th percentile. Single measurements beyond this range (outliers) are indicated as stars. The box plots present both the range and central tendencies of the data and allow for a visual comparison of the results among sampling stations. These plots are particularly appropriate for displaying fecal coliform data because Massachusetts fecal coliform standards are written in terms of percentiles: class B and SB waters should have a geometric mean fecal coliform count of 200 CFU/100 ml or less, with 90 percent of the samples having less than 400 CFU/100 ml. Thus, waters meeting fecal coliform standards will have a geometric mean count of 200 CFU/100 ml or less, and, on the box plots, the top horizontal line on the box (90th percentile) will be below 400 CFU/100 ml. For Enterococcus, EPA water quality guidelines recommend a "steady state" geometric mean of 33 CFU/100 ml, with a "single-sample allowable density" of 151 CFU/100 ml for fresh water infrequently used for full body contact recreation. The fecal coliform and *Enterococcus* count data are displayed on a logarithmic scale in all the box plots.

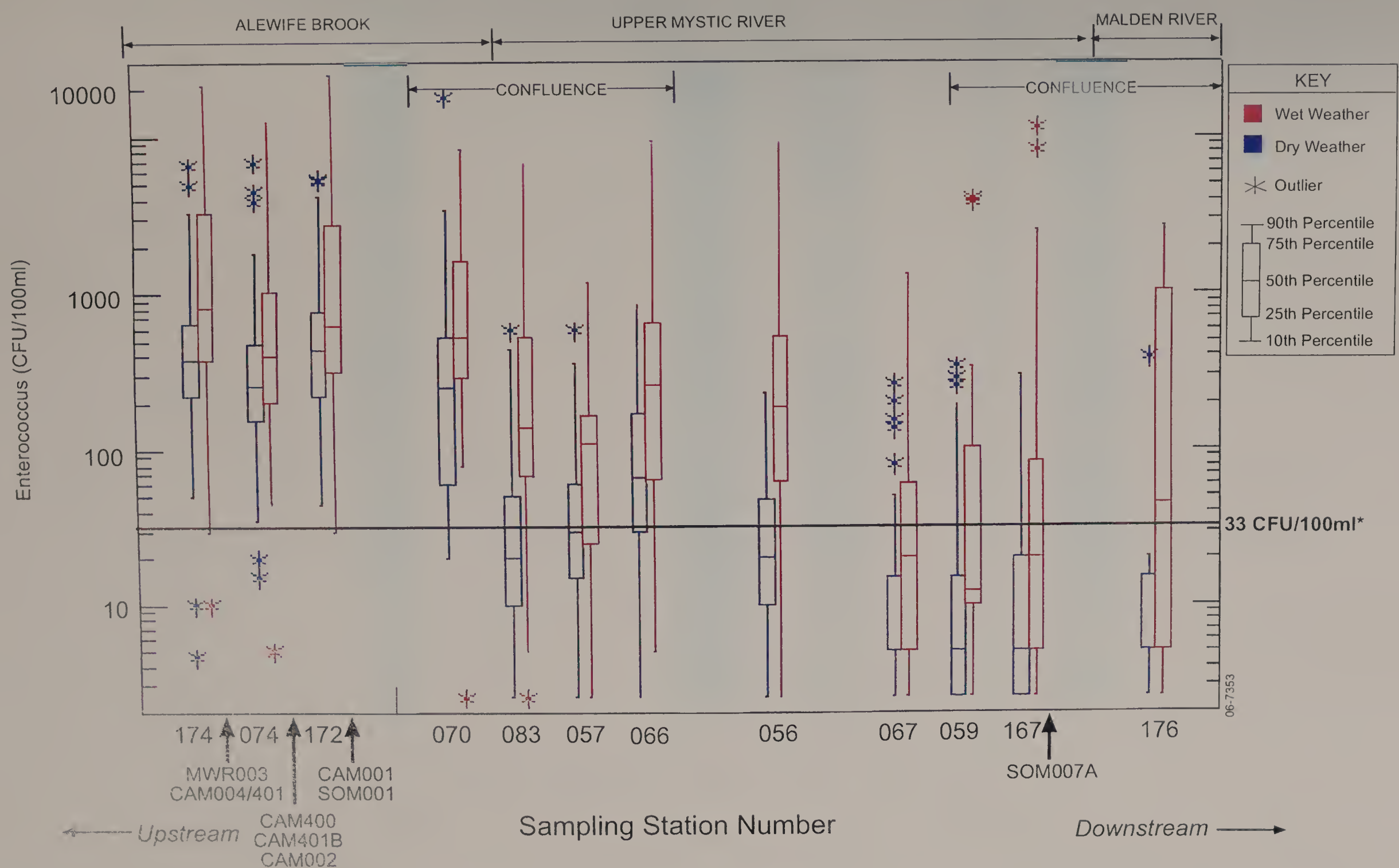
In reviewing Figure 4-2, the following observations are noted:

- In dry weather, the 25th percentile of fecal coliform bacteria samples at each location in Alewife Brook were above the Class B standard of 200 counts/100ml.
- In wet weather, the fecal coliform samples in Alewife Brook trended higher than the dry weather samples, although there was substantial overlap in the "boxes"
- Fecal coliform bacteria concentrations in the Mystic River were on average lower than the samples in Alewife Brook



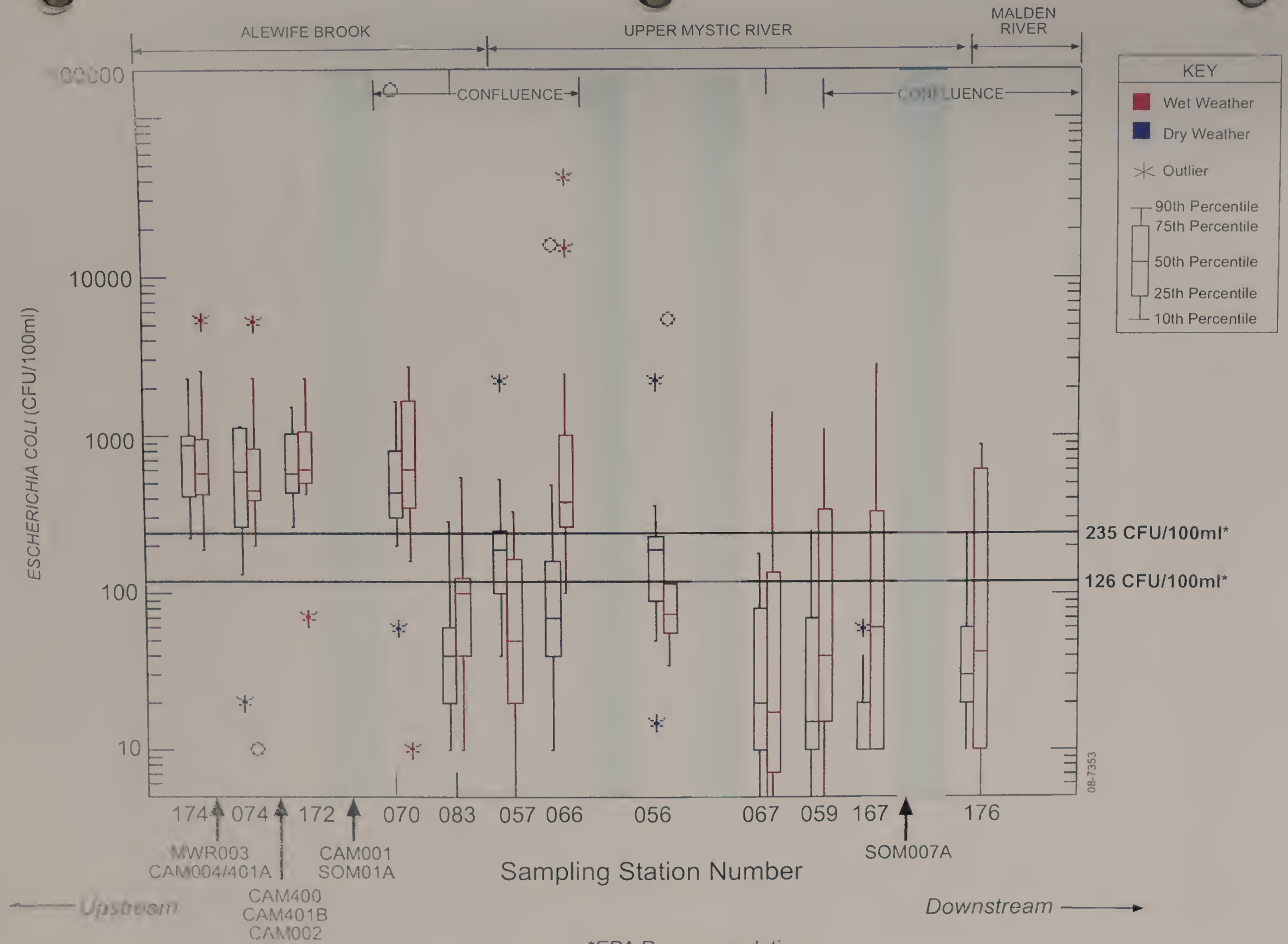
*MA Class B water quality standards :
200 CFU/100ml (geometric mean), 400 CFU/100ml (90th percentile)

FIGURE 4-2. PERCENTILE BOX PLOTS OF *FECAL COLIFORM* AT SAMPLING STATIONS IN ALEWIFE BROOK/UPPER MYSTIC RIVER, 1999-2002



*EPA Recommendations :
33 CFU/100ml (geometric mean)

FIGURE 4-3. PERCENTILE BOX PLOTS OF *ENTEROCOCCUS* AT SAMPLING STATIONS IN ALEWIFE BROOK/UPPER MYSTIC RIVER, 1999-2002



*EPA Recommendations:
126 CFU/100ml (geometric mean), 235 CFU/100ml (single sample max.)

FIGURE 4-3A . PERCENTILE BOX PLOTS OF *ESCHERICHIA COLI* AT SAMPLING STATIONS IN ALEWIFE BROOK/UPPER MYSTIC RIVER, 2002

- In dry weather, one sample location in the Mystic River had the 50th percentile fecal coliform concentration above the Class B standard of 200 counts/100ml. At three of the sampling locations in the Mystic River, the 75th percentile fecal coliform concentrations were less than the Class B standard in dry weather.

- In wet weather, the 50th percentile fecal coliform concentrations at four of the sampling locations on the Mystic River were less than the Class B standard.

In general, these data indicated that in dry weather, fecal coliform concentrations in Alewife Brook are usually in excess of the Class B standard, and are often in excess of the former secondary contact recreation standard of 1,000 colonies/100mL. In wet weather, fecal coliform bacteria concentrations are usually in excess of the 1,000 colonies/100mL. In the Upper Mystic River, the upstream region near the Mystic/Alewife confluence is usually just above or just below the Class B standard in dry weather, while downstream regions generally meet Class B water quality standards in dry weather. In wet weather, fecal coliform bacteria concentrations are higher than in dry weather, but generally not as high as the concentrations in Alewife Brook.

The trends in *Enterococcus* data presented in Figure 4-3 were generally similar to the fecal coliform data. There appeared to be somewhat more of a differentiation between the range of dry weather and wet weather samples at each station for the *Enterococcus* data than for the fecal coliform data. In general, fewer samples met the *Enterococcus* geometric mean standard of 33 colonies/100mL than met the fecal coliform standard of 200 colonies/100mL, particularly in the areas of the Alewife Brook and Alewife/Mystic confluence. The *E. coli* data presented in Figure 4-3A represent a limited data set, but the relative trends are generally similar to the other two bacterial indicators.

Other Sampling Programs

In addition to the data collected by the MWRA in support of the variance requirements, other organizations collected samples in the Upper Mystic River and Alewife Brook during the 1998 through 2002 period. Data from three studies were compared to the data collected by the

MWRA to check for consistency. The studies from which other data were obtained are summarized below.

United States Geological Survey (USGS) Data. Between October 1998 and January 2000, water quality data were collected by the USGS at two stations on the Mystic River and a third station on the Alewife Brook. Samples were collected and analyzed for dissolved oxygen, nitrogen (nitrite and ammonia), phosphorous, pH, *E. coli* bacteria and fecal coliform bacteria.

Mystic River Watershed Association (MyRWA) Water Quality Monitoring. The Mystic River Watershed Association, through its Mystic Monitoring Network (MMN) program, periodically collects water samples from the Alewife Brook at Broadway. Due to the elevated levels of fecal coliform bacteria detected from this monitoring, the MMN implemented ancillary studies along Alewife Brook to better characterize the bacteria concentrations.

One of the ancillary studies implemented by the MMN was the collection of water quality samples from the approximate center of Alewife Brook every 0.10 miles from the confluence with the Mystic River to Little Pond. Two sampling events were conducted between 2001 and 2002. Samples were analyzed for *E. coli* and *Enterococcus* bacteria, pH, temperature, dissolved oxygen, conductivity, and salinity. Bacteria samples were collected in a 100mL sample bottle attached to a pole, dipped into the stream flow and analyzed at the EPA Region 1 Laboratory. The temperature, pH, and dissolved oxygen were collected using a YSI-85 meter and pH probe immersed directly into the streamflow. In accordance with the MyRWA Quality Assurance Project Plan (QAPP), one out of every ten samples taken was a duplicate.

Tufts University. Tufts University master's degree candidate, Beth Higgins, collected water quality data at five locations along the Alewife Brook during the summer and fall of 2000. Samples were collected during one dry weather (date unknown) and two wet weather events (July 26-28, 2000 and September 14-16, 2000). During the two wet weather events, samples were collected at evenly spaced time intervals across the storm - 0hr, 1, hr, 2hr, 3hr, and 4hr. In

addition, both pre- and post-storm samples were collected. Total coliform, fecal coliform, and *E. coli* bacteria concentrations and conductivity were measured.

Comparison of MWRA data to Other Studies

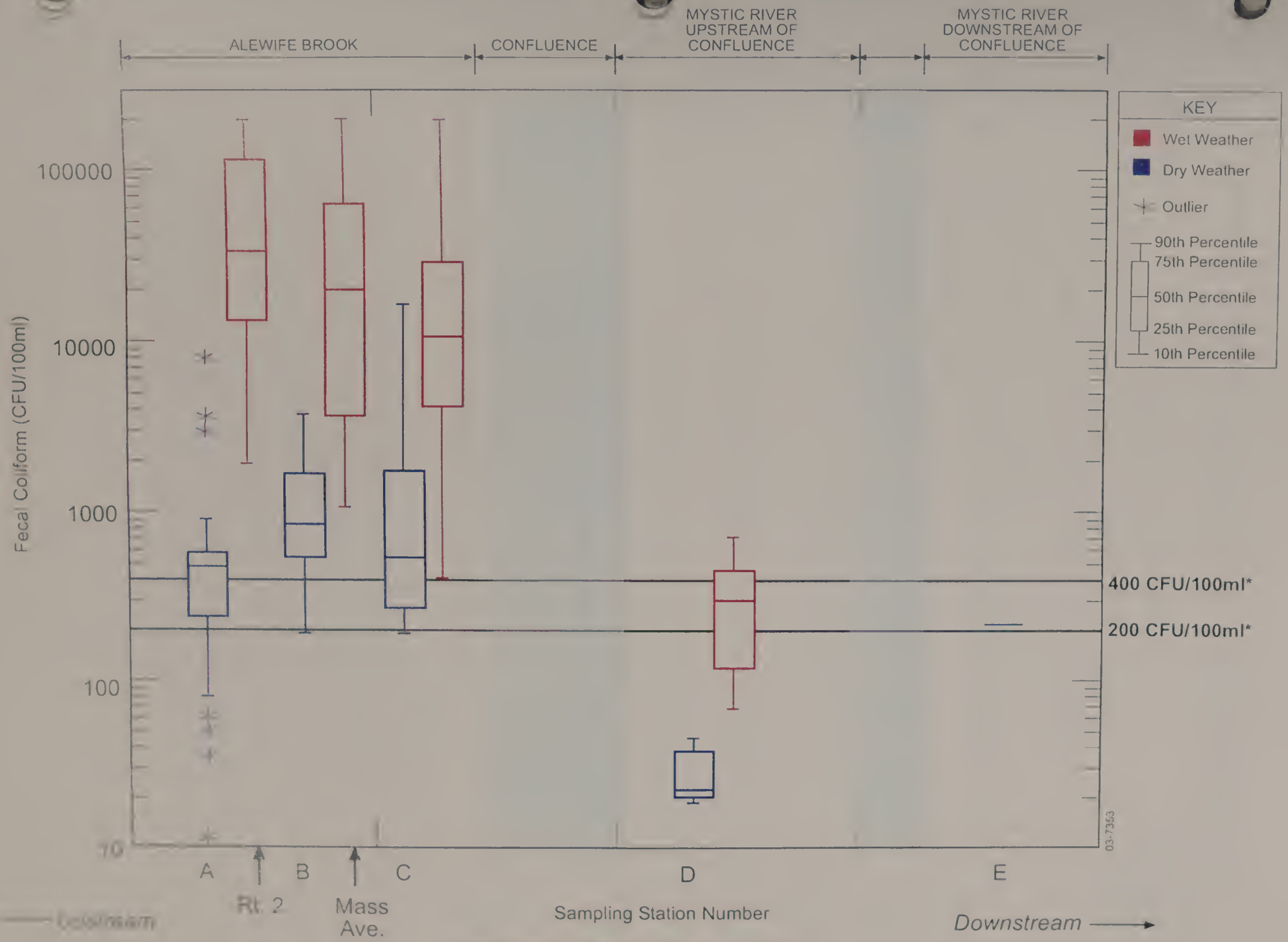
To compare the water quality data from the other studies to the water quality collected by the MWRA, the raw data from the other studies was segregated into "wet" and "dry" days using the same RMS criteria as described above and plotted in a box plot (Figure 4-4). Since the sampling was conducted a locations different than the MWRA station locations, the data from the three "other studies" were grouped into 5 different water segment categories (Table 4-6).

At stations A, B, and C, along the Alewife Brook, dry weather concentrations frequently exceeded the Class B standard during dry weather. During wet weather, concentrations measured at all three stations almost exclusively exceeded Class B standards. Dry weather data ranged from 200 to 1,000 colonies/100mL and wet weather samples ranged from 1,000 to 200,000 colonies/100mL.

At station D on the Mystic River, upstream of the confluence with the Alewife Brook (where there are no CSO inputs), dry weather samples were below the Class B standard and the wet weather samples generally exceeded the Class B standard.

Further downstream on the Mystic River at station E, only one dry weather sample was collected and it showed concentration slightly greater than the 200 colonies/100mL Class B standard.

In general, the box plots of fecal coliform data from the other studies showed greater differentiation between dry and wet weather samples than did the box plots of the MWRA data in Figure 4-2. The 50th percentile of the dry weather data in Alewife Brook for the other studies was below a level of 1,000 counts/100 ml, while it was above a level of 1,000 counts/100ml in the MWRA data. The wet weather data from the other studies seemed to trend somewhat higher than the MWRA data in Alewife Brook. Despite these differences, the data from the other



*MA Class B water quality standards:
200 CFU/100ml (geometric mean), 400 CFU/100ml (90th percentile).

FIGURE 4-4 . PERCENTILE BOX PLOTS OF *FECAL COLIFORM* AT SAMPLING STATIONS IN ALEWIFE BROOK/UPPER MYSTIC RIVER, 1999-2002

TABLE 4-6. GROUPING OF SAMPLE DATA FROM "OTHER STUDIES"

Station	Description of river/brook segment	MWRA Sampling stations included in segment
A	Little Pond to Alewife Brook, downstream of Rt. 2 bridge	174, 074
B	Alewife Brook, downstream of Rt. Bridge to Alewife Brook, downstream of Mass. Ave. bridge	172
C	Alewife Brook, downstream of Mass. Ave. bridge to confluence with the Mystic River	070
D	Mystic Lakes to Mystic River, upstream of confluence with Alewife Brook	083
E	Mystic River, confluence to Mystic River, downstream of I-93 bridge	057, 066, 056
F	Mystic River, downstream I-93 bridge to Mystic River, Ameila Earhart Dam	067, 059, 167

studies are generally within the range of data collected by MWRA. It would be expected that the MWRA data would exhibit a wider range of sample values, given the greater number of data points within the MWRA data set.

BASELINE RECEIVING WATER QUALITY MODELING

A receiving water model was used to assess baseline water quality conditions in Alewife Brook and the Upper Mystic River. This model was originally calibrated in 1996 for use in support of the MWRA's CSO facilities planning activities. The model was updated based on more recent receiving water sampling, including data presented in the previous section. A description of the model is presented below, followed by a description of the update to the model and a comparison to recent sampling data. Baseline fecal coliform bacteria concentration plots are then presented

for the 3-month and 1-year storms. Performance of the recommended CSO control plan in comparison to baseline conditions is presented in Chapter Six.

Model Description

A water quality model was originally developed for the Alewife Brook/Upper Mystic River receiving water during CSO facilities planning, using the dynamic one-dimensional stream model CE-Qual-Riv1. Since CE-Qual-Riv1 is a one-dimensional model, the equations for flow and water quality constituent concentrations are vertically and cross-sectionally averaged. Being dynamic, the model can simulate time-varying flow, surface elevation, and constituent concentrations. This ability makes it well-suited to predict the water quality impacts of wet weather events during which upstream flows, stormwater runoff, CSO flows, and their associated pollutant loads vary considerably.

The model simulates river networks consisting of one or more branches, schematized in the model as reaches made up of individual segments. Width, cross-sectional profile, and bottom elevation are specified at the upstream end of each segment, in addition to segment length. Either a flow or depth time series is specified as the upstream boundary condition of each reach. A flow or depth time series or rating curve forms the downstream boundary condition. Boundary conditions are calculated automatically for reaches downstream of reach junctions and control structures.

The CE-Qual-Riv1 hydrodynamic module, Riv1H, computes flows, depths, and surface elevations for each segment at every time step by solving the fully dynamic conservation of mass and momentum equations for open channel flow. Hydrodynamic calculations are saved at each time step to an interface file that is read by the water quality module, Riv1Q, during water quality simulations.

Details of the various dispersion coefficients, decay rates, and distribution coefficients used in the model to compute pollutant concentrations are summarized in the December 1996 *Draft*

Technical Memorandum: Development and Calibration of Water Quality Models for Boston Harbor, Charles River Basin, and Mystic River/Alewife Brook. Flow inputs along river segments, such as stormwater runoff and CSO flows, were specified as lateral inflows to individual segments in terms of flow per unit length of river carrying specified water quality constituent concentrations.

The hydrodynamic module requires input describing river discretization and bathymetry, boundary conditions, and lateral inflows. The Upper Mystic River receiving water model extends from the Amelia Earhart Dam in Somerville/Everett upstream to Lower Mystic Lake in Arlington. Flow from the Malden River, which is tributary to the Upper Mystic River just upstream of the Amelia Earhart Dam, is simulated as a lateral inflow based on the runoff areas tributary to the Malden River. The Alewife Brook segment of the model extends from the confluence with the Upper Mystic River upstream to the Cambridge/Belmont town line. Figure 4-1 (in map pocket) presents the locations of the water quality sampling stations along the Alewife/Upper Mystic receiving water segment. The Alewife Brook portion of the model has been subdivided into 19 segments, and the Upper Mystic River reach into 37 segments.

Model Calibration Update

The calibration of the Riv-1 model was reviewed under both dry weather and wet weather conditions. The results of this effort are discussed below.

Dry Weather Calibration Update. The receiving water model was originally calibrated during CSO facilities planning in 1996 using field data developed and/or available at that time. In order to take into account changes to baseline dry weather conditions that may have occurred since the original calibration in 1996, the modeled dry weather flow conditions were compared to recent dry weather sampling data. The geometric means of dry weather samples collected by MWRA at various sampling stations in Alewife Brook and the Upper Mystic River during the period of 1998–2002 were compared to the means for samples taken just in 2002. The results indicated little variation in the means, suggesting that the 2002 data were representative of dry weather

conditions during the period of 1998 to 2002. Some variation, however, was found between these data and the predicted dry weather concentrations based on the 1996 calibration. Therefore, the fecal coliform density profiles in Alewife Brook and the Mystic River under dry weather conditions were recalibrated to the 2002 data. Figure 4-5 presents a plot of the geometric means of dry weather sampling data from 2002, and the recalibrated baseline dry weather fecal coliform concentrations in the Riv-1 model. As indicated in Figure 4-5, the dry weather calibration closely matches the sampling data.

Wet Weather Calibration Update. As described earlier in this chapter, extensive stormwater sampling was conducted during the Variance period, and a limited program of CSO sampling was also undertaken. Based on the results of the stormwater sampling presented above, the average concentration of fecal coliform in separate stormwater used in the modeling evaluations was revised to 16, 235 counts/100ml. The results of the limited sampling of combined sewage were generally consistent with the average value for fecal coliform bacteria of 538,000 counts/100ml previously used in the CSO facilities plan and in the *Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook*. The average concentrations of fecal coliform bacteria, TSS and BOD in CSO and stormwater used for loading calculations and receiving water modeling are summarized in Table 4-7.

As a check of the wet weather calibration of the Riv-1 model, the model was run for three storm events for which in-stream sampling data were available (the June 5-7, 2002, September 23, 2002 and November 16-17, 2002 storms). The model configuration included the updated fecal coliform density profile in Alewife Brook and the Mystic River under dry-weather conditions and the updated average fecal coliform concentration in stormwater. The SWMM model for the Alewife Brook area was run using the hyetographs from each storm to generate CSO and stormwater flows. Model output was plotted for the timestep corresponding to approximately the time that the in-stream samples were taken. Figures 4-6, 4-7, and 4-8 present the linear plots of calculated and measured fecal coliform densities for these three storms. The rainfall characteristics of each of these storms, and the total predicted CSO volume, are presented in Table 4-8.

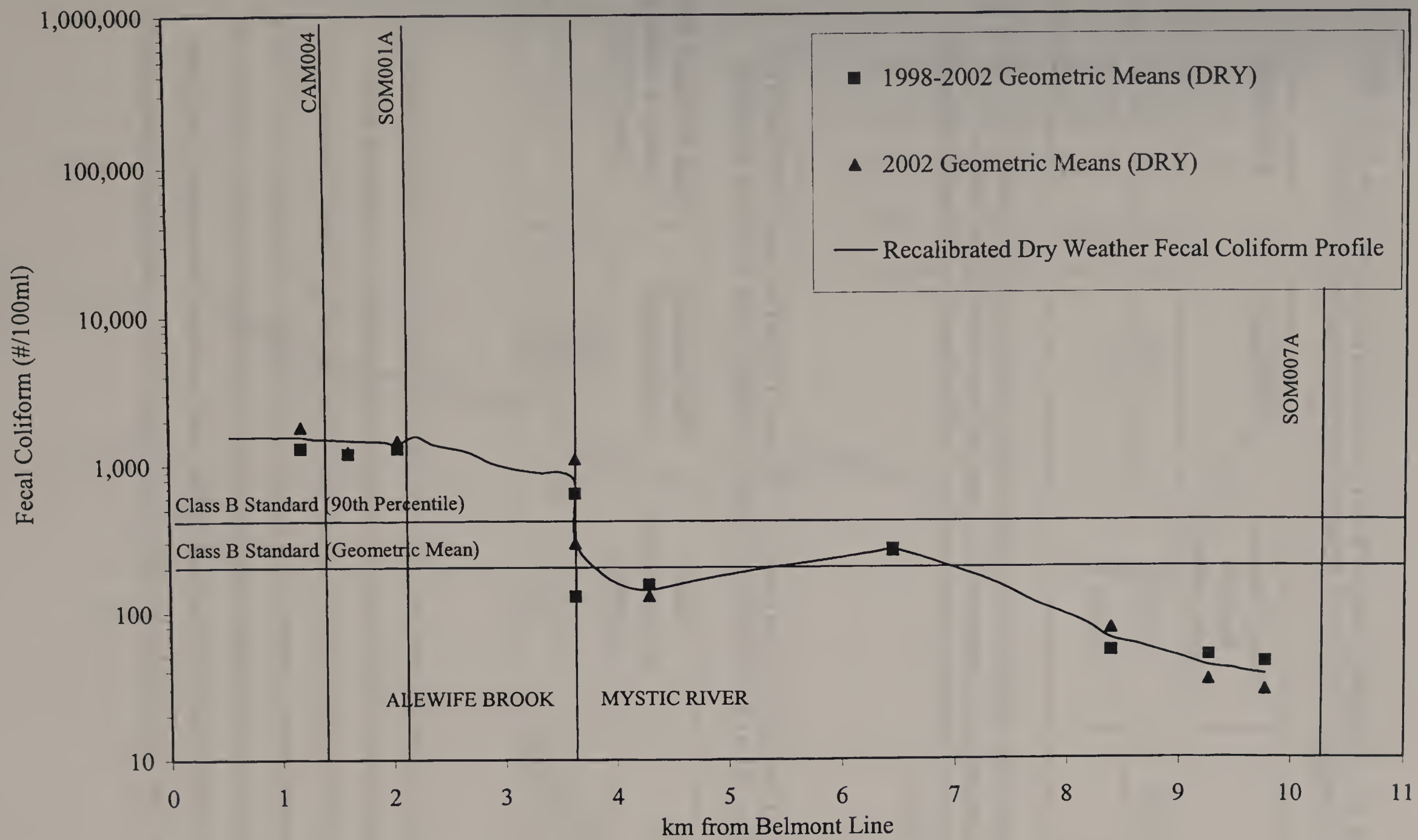


FIGURE 4-5. ALEWIFE BROOK/MYSTIC RIVER DRY WEATHER FECAL COLIFORM PROFILE

TABLE 4-7. AVERAGE POLLUTANT CONCENTRATIONS FOR CSO AND STORMWATER USED FOR RECEIVING WATER MODELING

	Fecal Coliform Bacteria (counts/100ml)	TSS (mg/l)	BOD (mg/l)
Untreated CSO(1)	538,000	140	78
Untreated Stormwater	16,235 (2)	38(1)	20(1)

Notes: (1) Refer to the MWRA's *Draft System Master Plan Baseline Assessment*, June 1994, for more detail on the source of the average pollutant concentration values.
(2) Refer to the discussion of average fecal coliform density in stormwater presented above.

TABLE 4-8. SUMMARY OF RAINFALL CHARACTERISTICS AND PREDICTED CSO VOLUME TO ALEWIFE BROOK FOR CALIBRATION UPDATE STORMS

Date	Total Accumulation (Inches)	Peak Intensity (Inches/hour)	Total Predicted CSO Volume to Alewife Brook (MG)
June 5-7, 2002	1.77	0.24	0.0
September 23, 2002	1.20	0.36	0.97
November 16-17, 2002	2.21	0.23	0.31

In reviewing the calibration plots, the intent is not that the model exactly match the sample points, but rather that the model presents a reasonable representation of conditions in the receiving water for a range of storms. Local variations in the timing of peak flows and in site-specific concentrations are expected when interpreting bacterial sampling data. For the June 6, 2002 storm (Figure 4-6), the model under-predicted the fecal coliform densities at the time the samples were taken in Alewife Brook, and slightly over-predicted the densities in the Upper Mystic River. For the September 22, 2002 storm (Figure 4-7), no sampling data were available

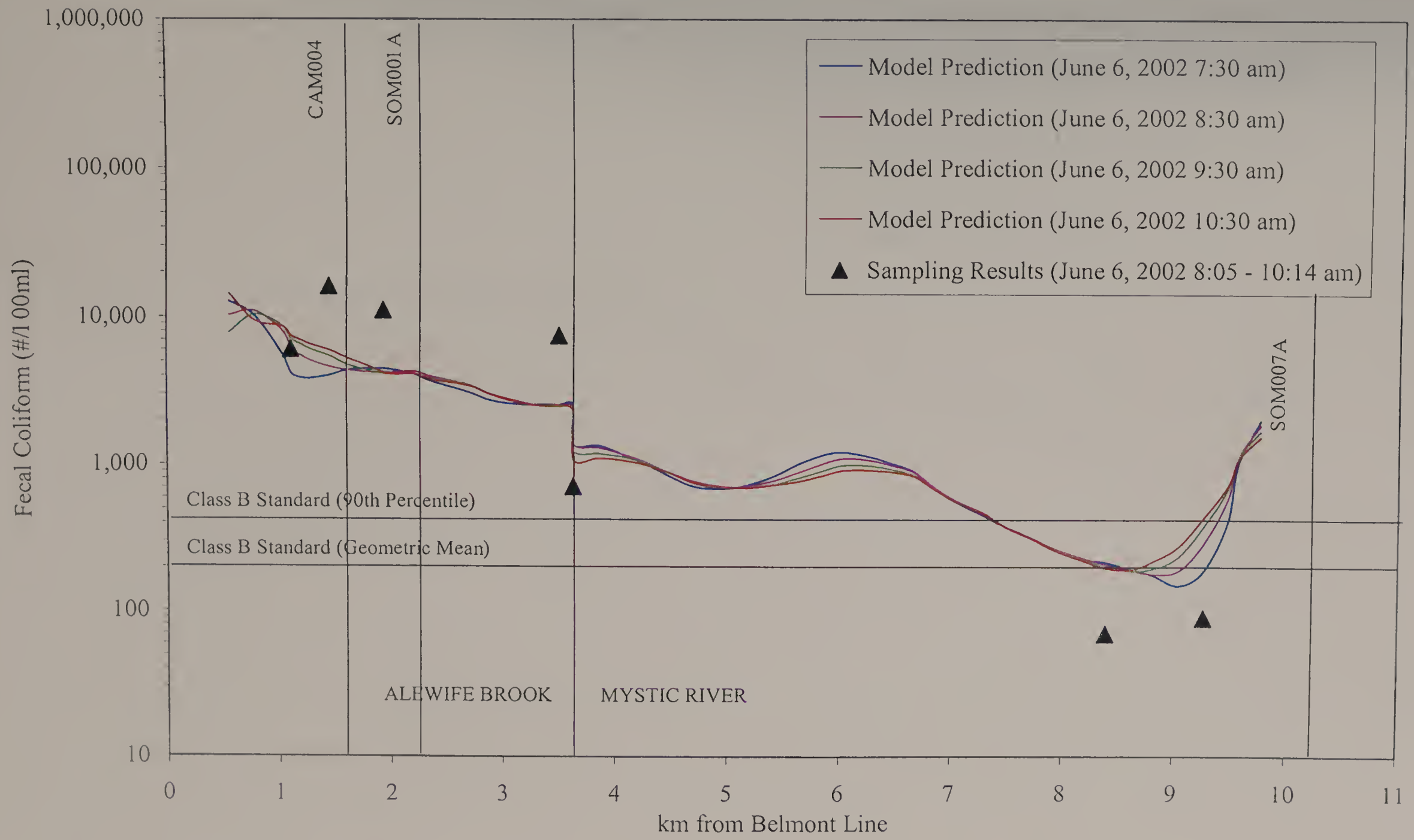


FIGURE 4-6. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
June 6, 2002 Storm Event

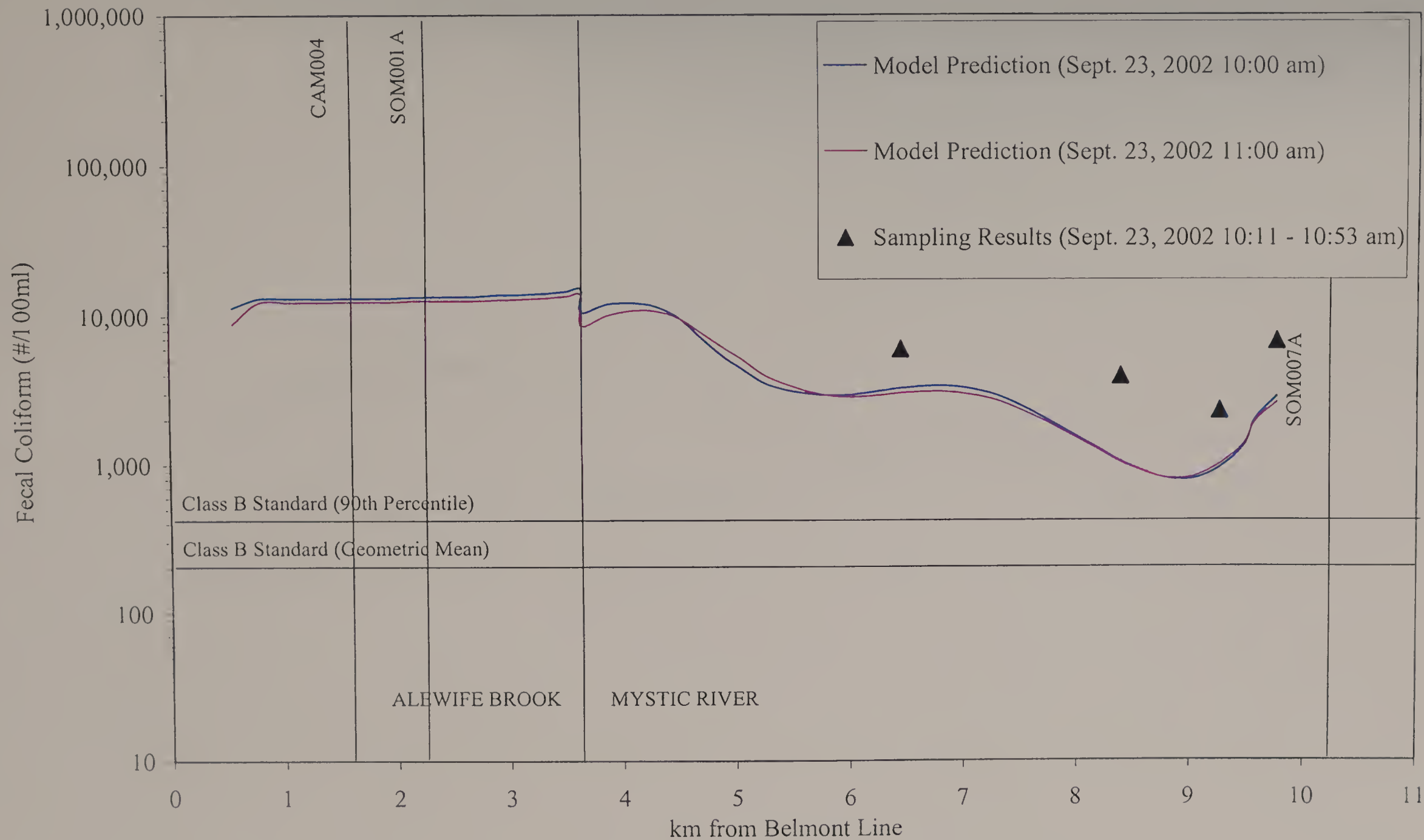


FIGURE 4-7. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
September 22, 2002 Storm Event

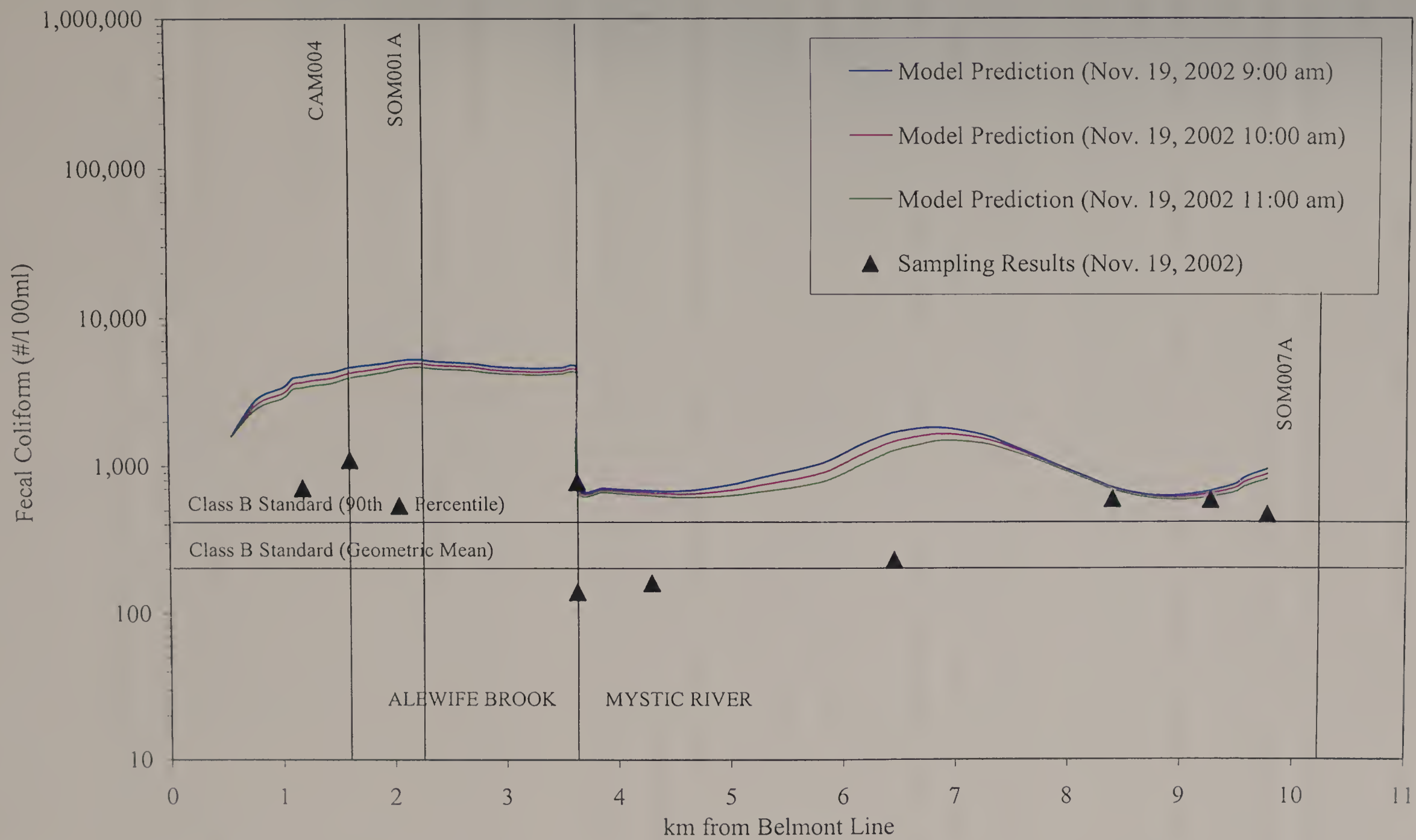


FIGURE 4-8. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
November 16, 2002 Storm Event

in Alewife Brook, and the model somewhat under-predicted that bacterial densities in the Upper Mystic. For the November 16, 2002 storm (Figure 4-8), the model over-predicted the fecal coliform density in Alewife Brook; matched the densities at one location at the confluence of Alewife Brook and the Upper Mystic River and at the three downstream locations on the Upper Mystic; and over-predicted the densities at three sampling locations in the upper portion of the Upper Mystic. It should be noted that for the November 16 storm, the sampled values in Alewife Brook were generally between the 10th and 25th percentile for wet weather samples based on previous MWRA sampling data presented in Figure 4-2.

To account for variations in the timing of sample collection with respect to the timing of peak flows, plots were also developed for concentration versus time for specific sampling locations. Figure 4-9 indicates predicted fecal coliform density versus time at sampling station 174 for the June 6, 2002 storm. The sample point is indicated on the plot at the time the sample was taken in the field. For this location, the value of the sample happens to fall exactly on the line of predicted concentration. Figure 4-10 presents a similar plot for sampling station 172 for the June 6, 2002 storm. On this plot, the sampled point is offset from the predicted concentration. At the time the sample was taken, the model under-predicted the concentration. Shortly after the sample was taken, however, the modeled concentration in the receiving water reached the level of the sample. Additional plots of concentration versus time for the individual sampling stations are included in the Appendix E.

Based on review of these plots, the receiving water model was determined to be sufficiently calibrated to represent relative impacts of CSO, stormwater, and dry weather inputs to Alewife Brook and the Upper Mystic River.

Baseline Conditions

The receiving water model for Alewife Brook and the Upper Mystic River was run based on output from the updated SWMM Alewife sub-model under current conditions and the revised recommended plan for the Alewife area, for the 3-month and 1-year storms. Data for outfall

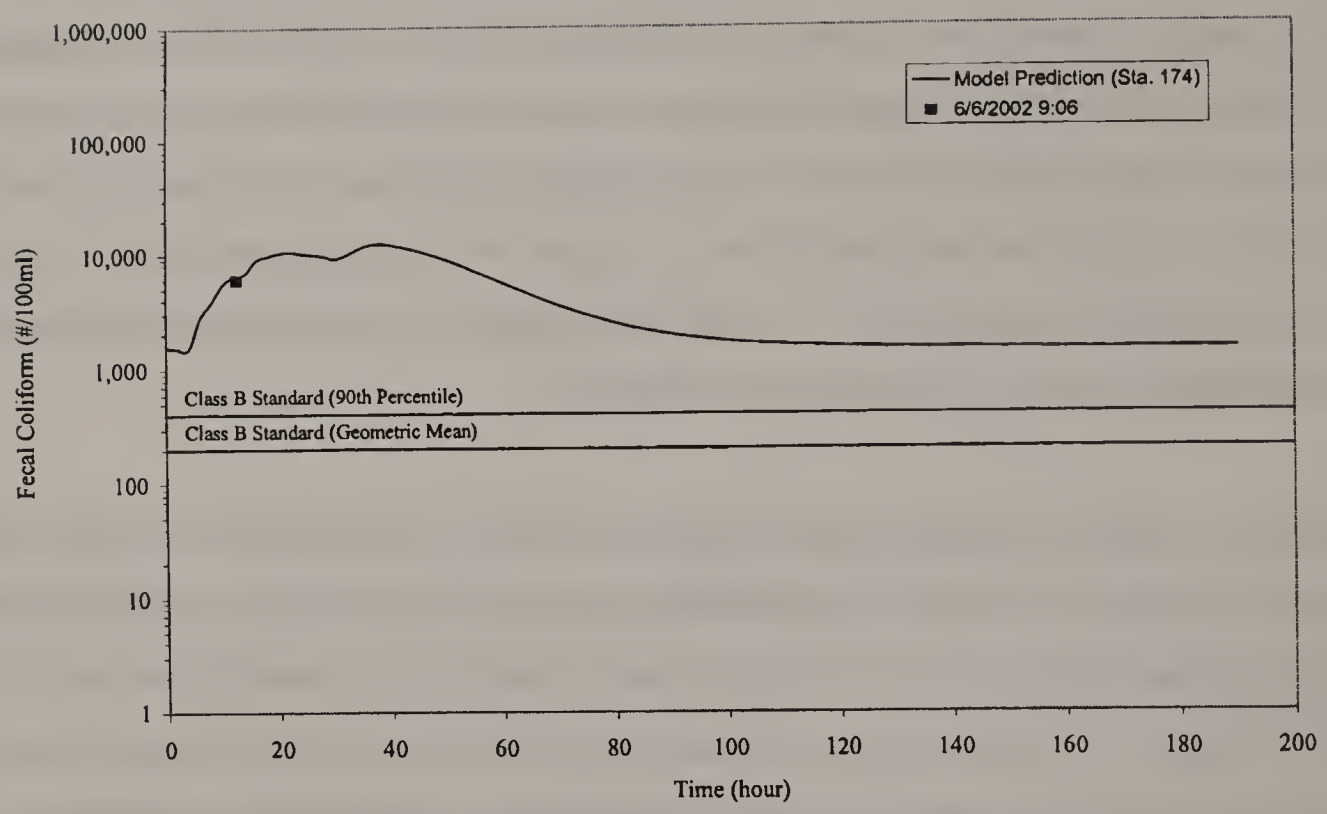


FIGURE 4-9. PREDICTED VS. MEASURED FECAL COLIFORM DENSITY AT STATION 174, JUNE 6, 2002 STORM

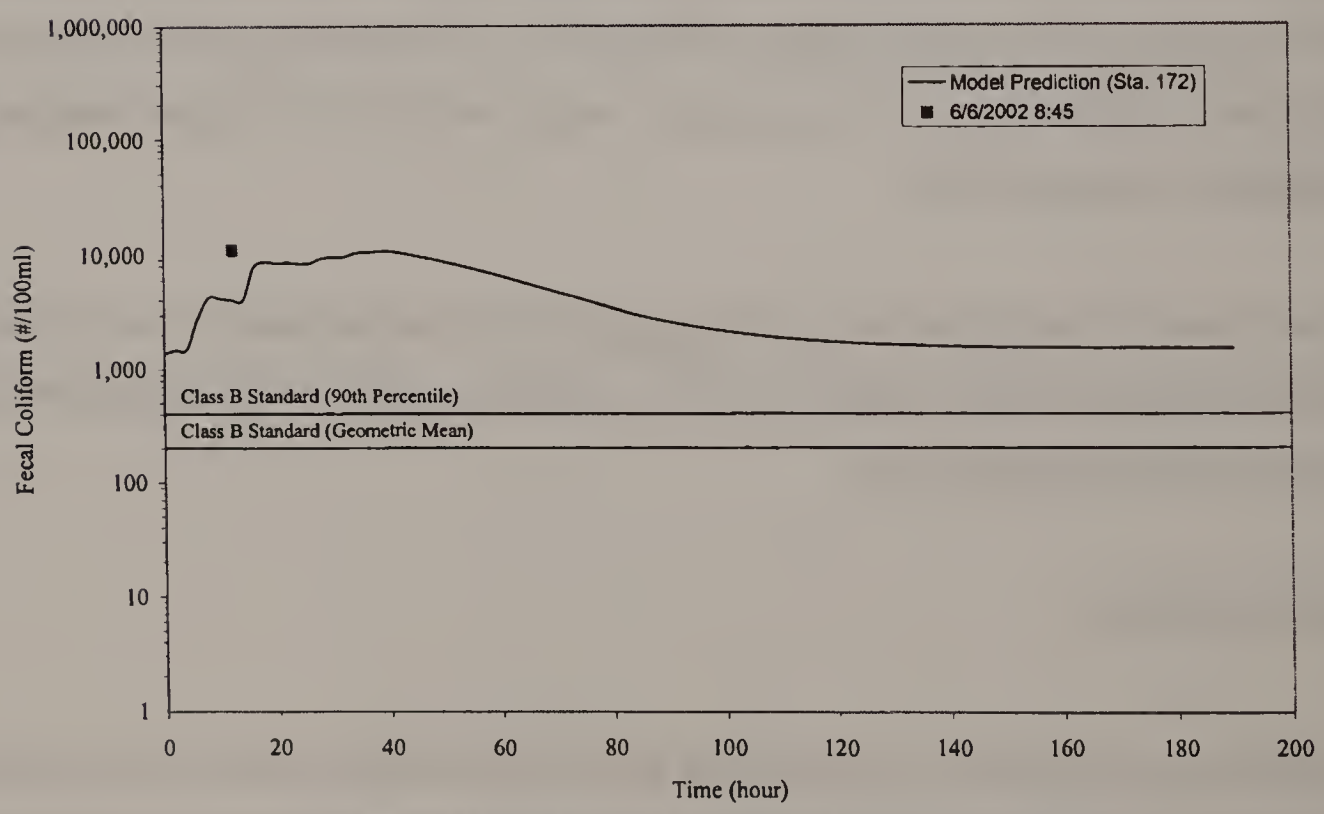


FIGURE 4-10. PREDICTED VS. MEASURED FECAL COLIFORM DENSITY AT STATION 172, JUNE 6, 2002 STORM

SOM007A, which is beyond the boundaries of the updated Alewife sub-model, were obtained from previous facilities planning model runs. Output was developed in the form of linear plots of fecal coliform density in the receiving water from the Belmont/Cambridge line at the upstream end of Alewife Brook to the Amelia Earhart Dam at the downstream end of the Upper Mystic River, at specific time intervals including dry weather prior to the storm, the peak of the storm, and 6, 24, 48, 72, 144, and 180 hours after the peak of the storm. Data were developed for existing conditions, all sources; existing conditions, non-CSO sources, only; and recommended plan, all sources. Comparing existing conditions, non-CSO sources, only, to recommended plan, all sources, provides an indication of the potential benefit of providing a higher level of CSO control.

Key landmarks along Alewife Brook and the Upper Mystic River are summarized by distance from the Cambridge/Belmont line in Table 4-9.

Linear Plots of Fecal Coliform Density. Figure 4-11 presents the fecal coliform density profile in Alewife Brook and the Upper Mystic River under dry weather conditions. As noted above, the dry weather densities were re-calibrated to 2002 data and data from 1998 to 2002. As indicated in Figure 4-11, the Class B standard of 200 counts/100 ml is exceeded in dry weather along the entire reach of Alewife Brook. The Class B standard continues to be violated in dry weather in the Upper Mystic River at the confluence with Alewife Brook and a point approximately 2.9 km downstream near Interstate 93.

Figures 4-12 through 4-18 present the fecal coliform profiles in Alewife Brook and the Upper Mystic River for the 3-month storm, at the peak of the storm, and 6, 24, 48, 72, 144, and 180 hours after the peak. Presented on the plots are existing conditions (all sources), existing conditions, non-CSO sources only, and recommended plan (all sources). The performance of the recommended plan is discussed in more detail in Chapter Six. The discussion herein focuses on

TABLE 4-9. ALEWIFE BROOK AND UPPER MYSTIC RIVER MODEL SEGMENTS

Receiving Water	Landmark	Cumulative Distance, km
Alewife Brook	Cambridge/Belmont Line	0.00
	CAM004/401A	1.26
	CAM400	1.76
	CAM002, CAM401B (Massachusetts Avenue)	1.92
	CAM001, SOM01A	2.03
	SOM SD-7 (formerly SOM001)	2.35
	SOM SD-11 (formerly SOM004)	3.47
	Confluence with Upper Mystic River	3.60
Upper Mystic River	Winthrop Street	5.06
	Interstate 93	6.48
	SOM SD-25 (formerly SOM007)	8.56
	SOM007A	9.21
	Amelia Earhart Dam	9.92

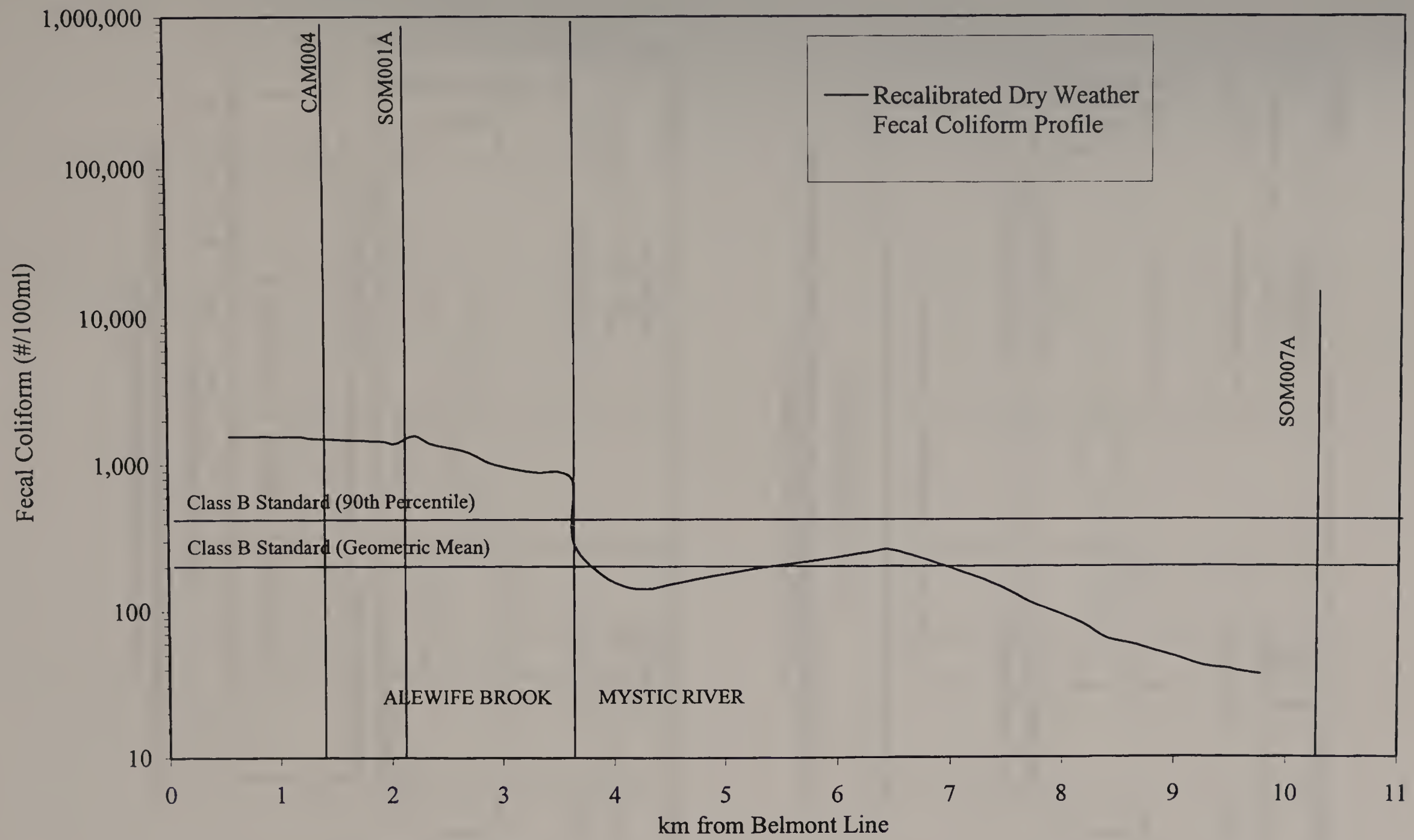


FIGURE 4-11. ALEWIFE BROOK/MYSTIC RIVER DRY WEATHER FECAL COLIFORM PROFILE

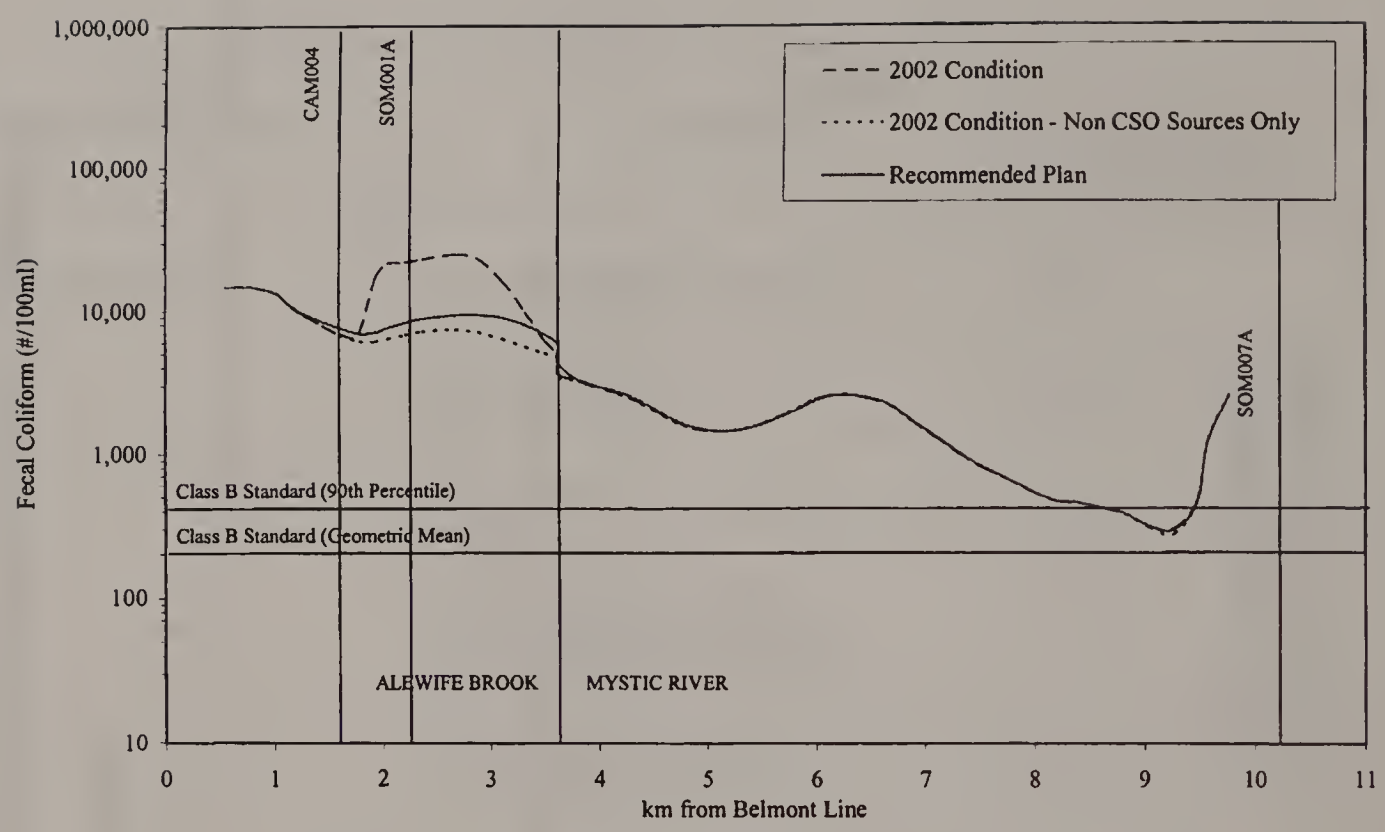


FIGURE 4-12. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
Peak of the 3-Month Storm

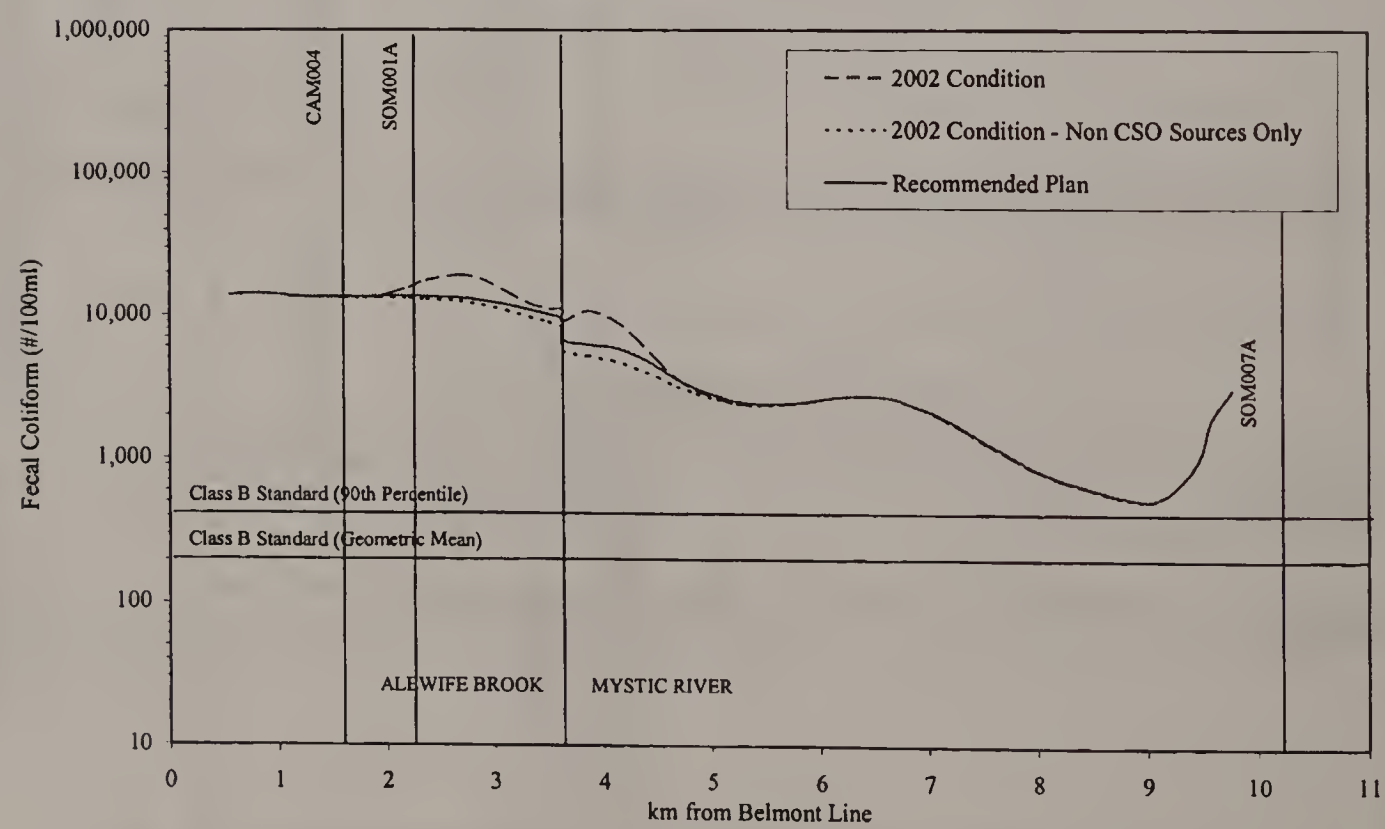


FIGURE 4-13. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
6 Hours After the Peak of the 3-Month Storm

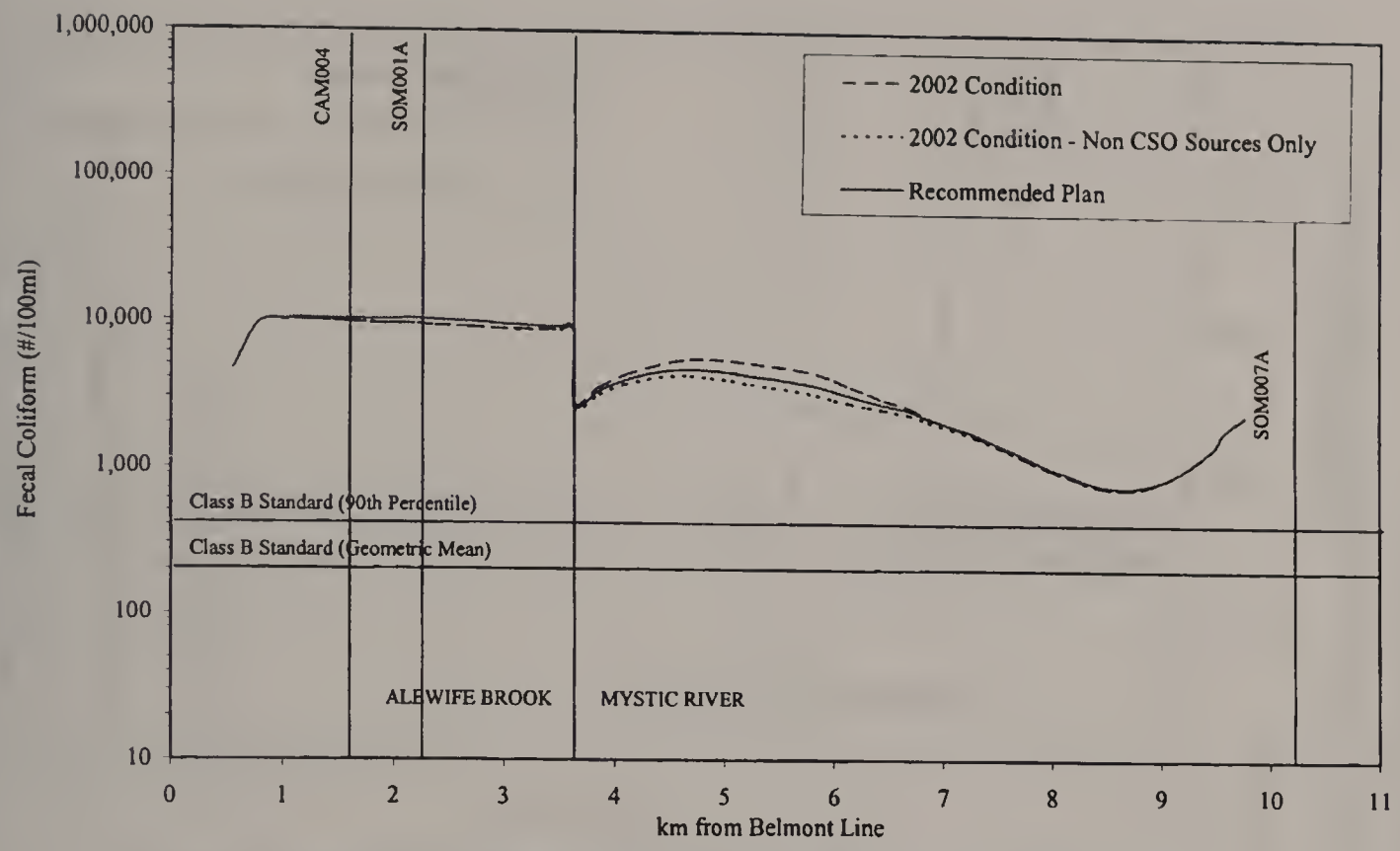


FIGURE 4-14. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
24 Hours After the Peak of the 3-Month Storm

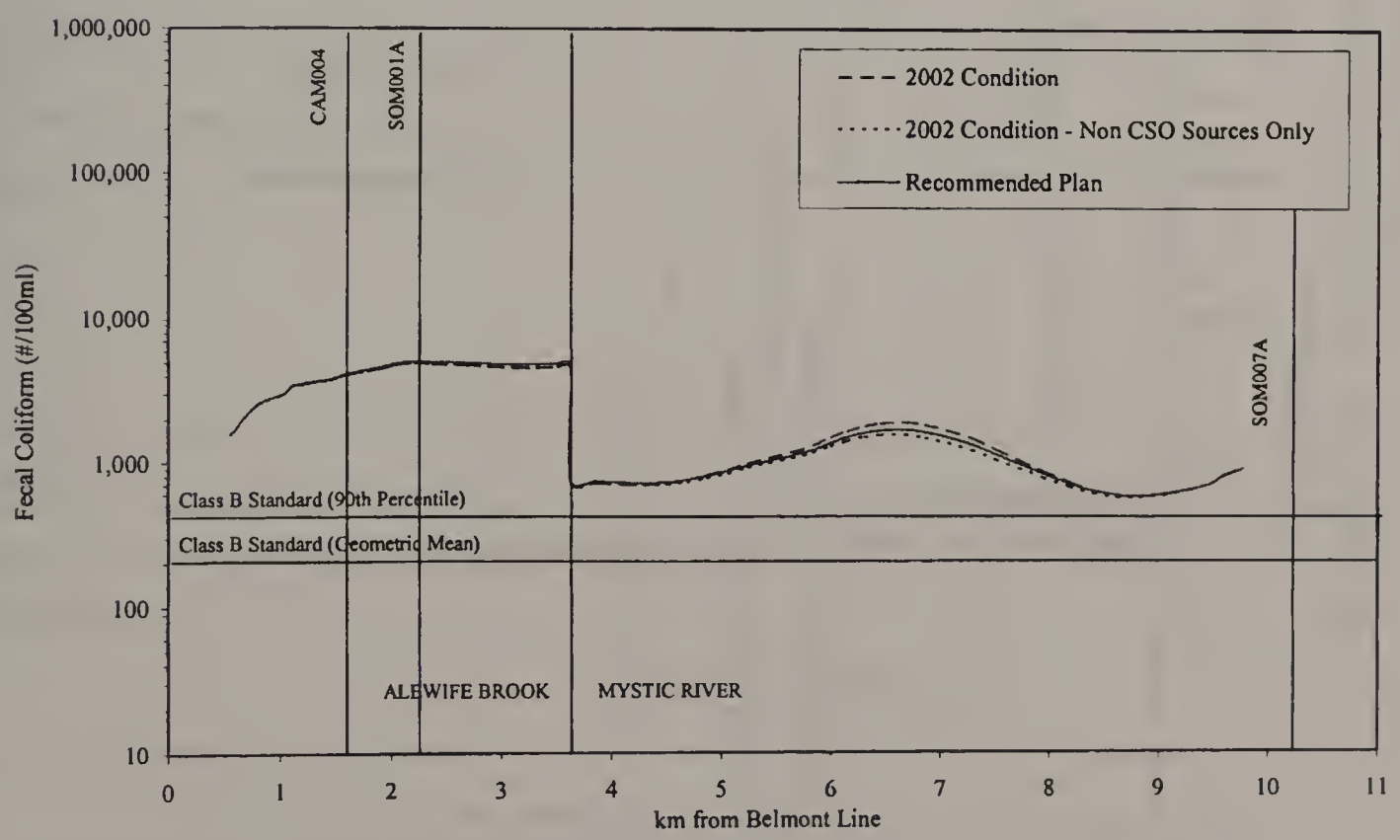


FIGURE 4-15. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
48 Hours After the Peak of the 3-Month Storm

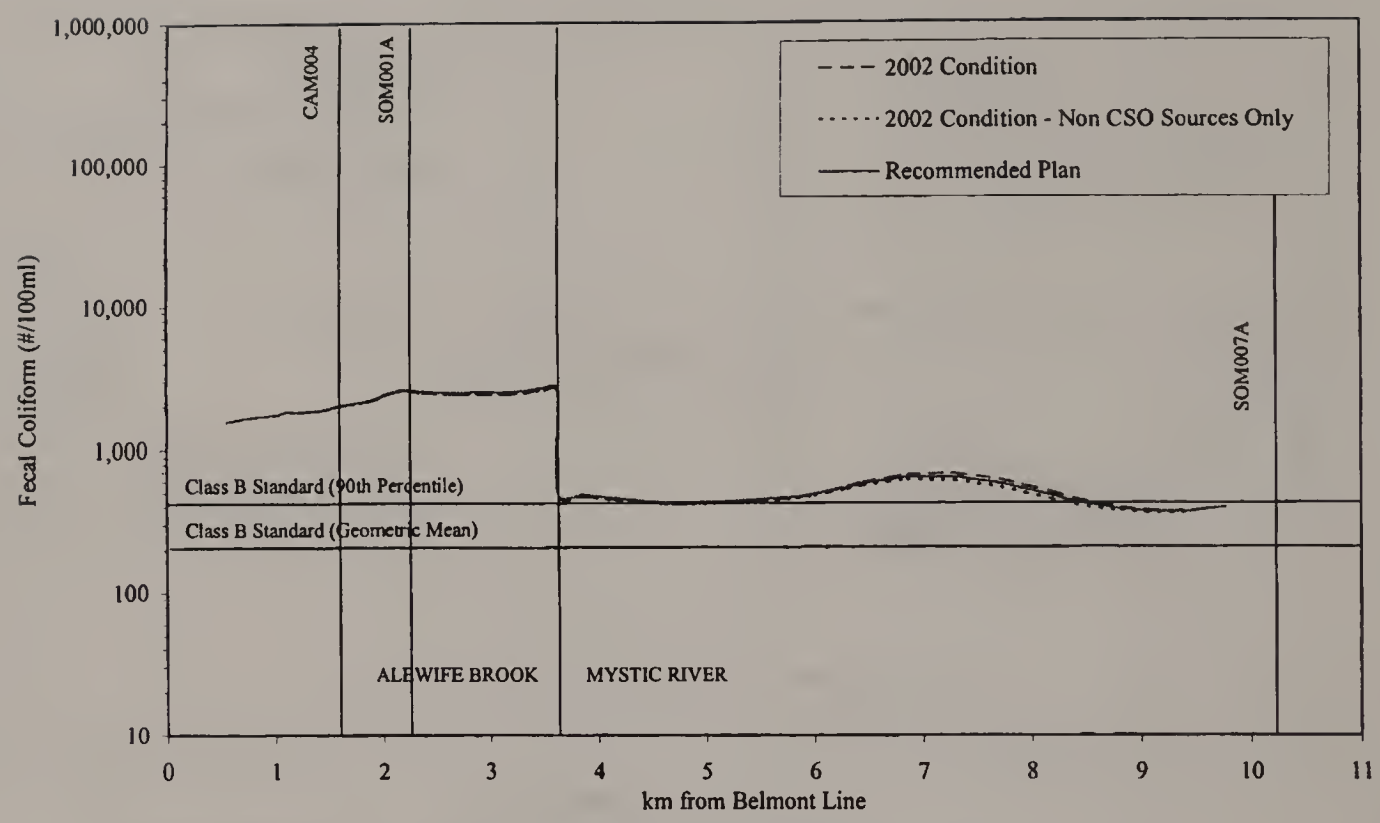


FIGURE 4-16. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
72 Hours After the Peak of the 3-Month Storm

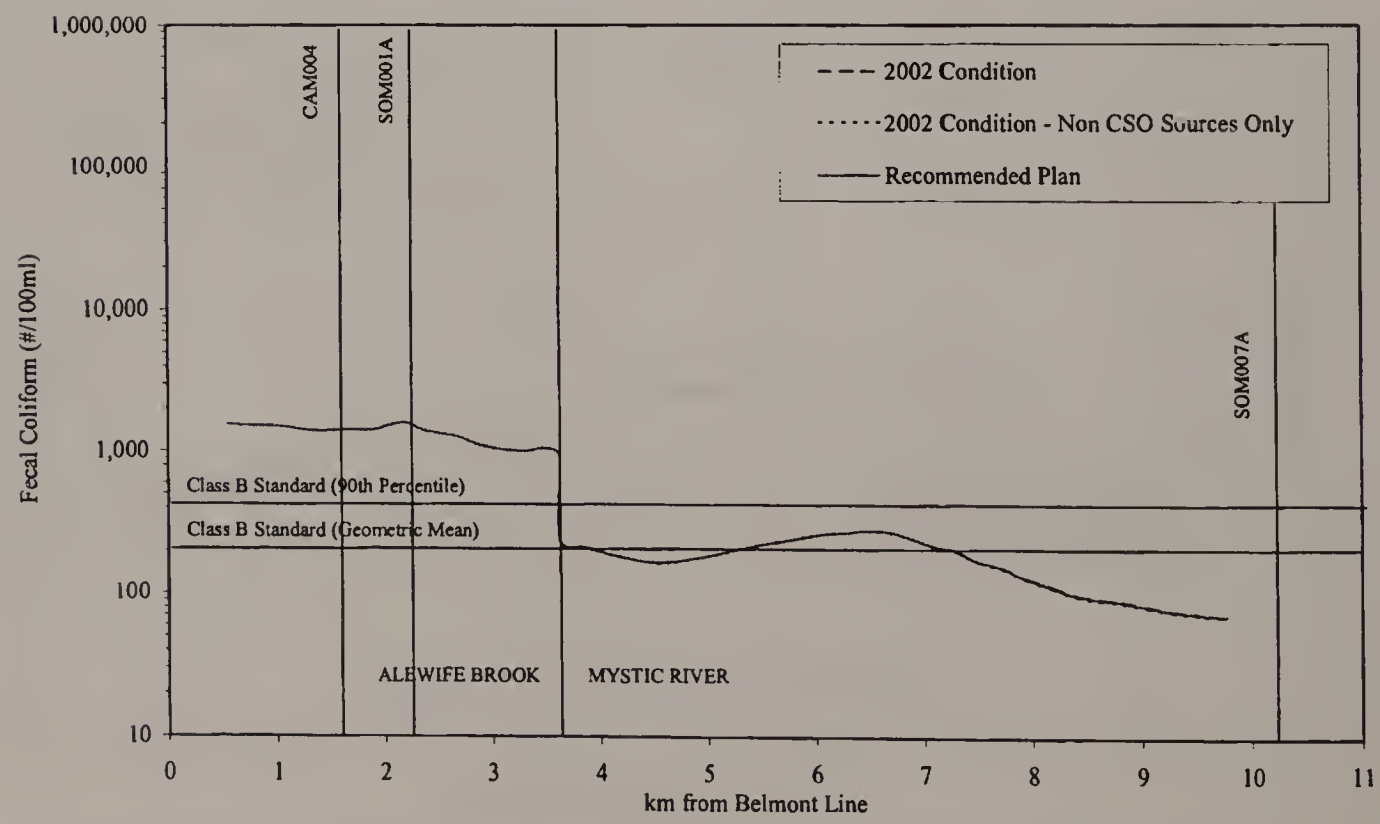


FIGURE 4-17. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
144 Hours After the Peak of the 3-Month Storm

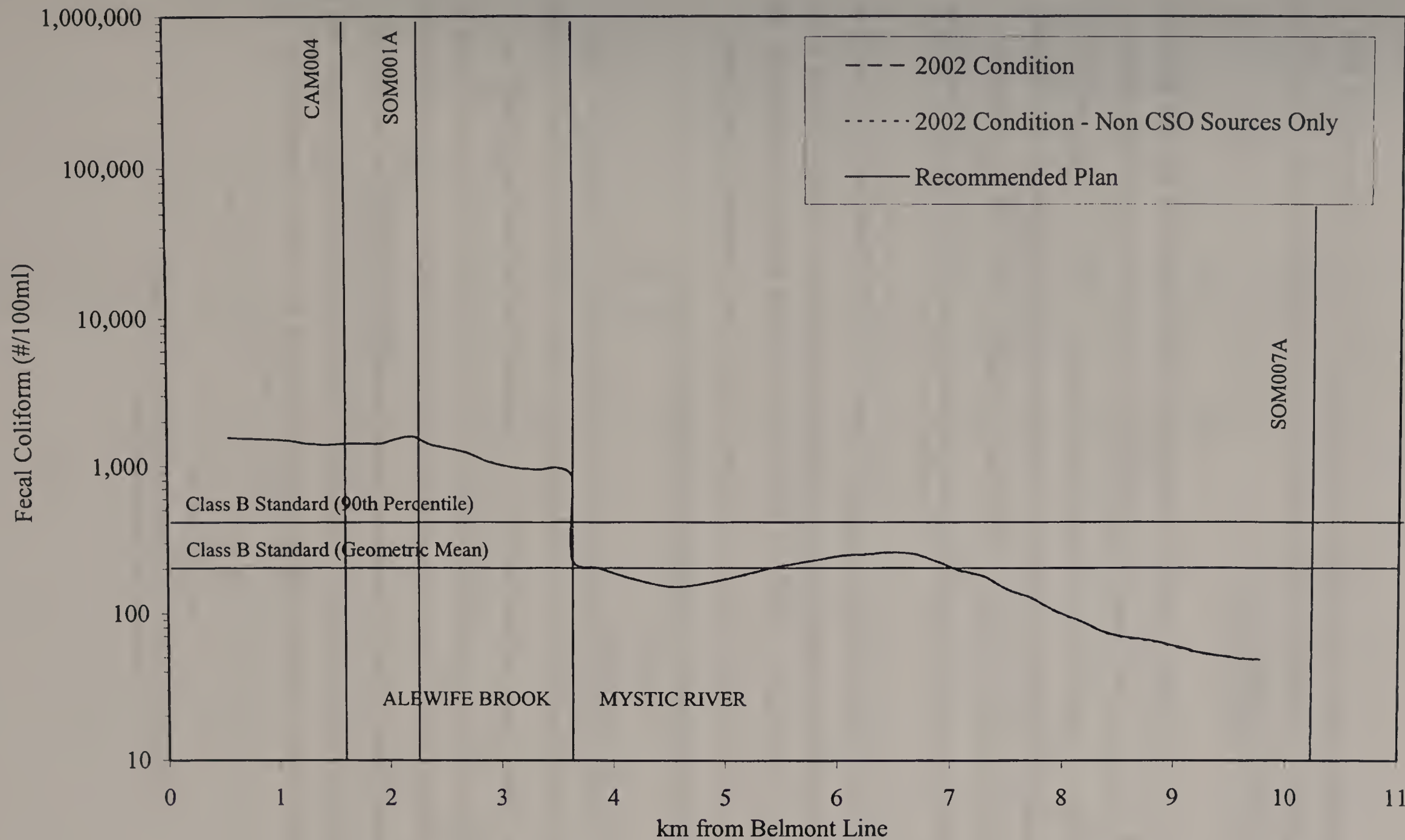


FIGURE 4-18. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
180 Hours After the Peak of the 3-Month Storm

the existing conditions plots. These figures indicate that for the 3-month storm, the total fecal coliform concentration in Alewife Brook is currently on the order of 20,000 counts/100 ml for up to six hours after the peak of the storm.

Without CSO, the concentrations would be on the order of 10,000 counts/100 ml. The impact of CSO on fecal coliform concentration in Alewife Brook is not discernable by 24 hours after the peak of the storm. A "hump" of elevated bacteria densities due to CSO can be observed moving downstream along the Mystic River starting at 6 hours after the peak of the storm. By 48 hours after the peak of the storm, the impact of CSO is less discernable, and by 144 hours after the peak of the storm, the bacteria concentrations have generally returned to dry weather conditions.

As noted above, the Class B standard is currently violated in Alewife Brook during dry weather. The impact of non-CSO wet weather sources on bacteria concentrations in Alewife Brook in the 3-month storm extends from the peak of the storm to approximately 84 hours after the peak. The impact of non-CSO wet weather sources on attainment of the Class B standard in the Mystic River extends to approximately 120 hours after the peak of the storm.

Figures 4-19 through 4-25 present the fecal coliform profiles in Alewife Brook and the Upper Mystic River for the 1-year storm, at the peak of the storm, and 6, 24, 48, 72, 144, and 180 hours after the peak. These figures indicate that for the 1-year storm, the fecal coliform density in Alewife Brook is on the order of 100,000 counts/100 ml for less than six hours after the peak of the storm. Without CSO, the peak concentration would be on the order of 15,000 counts/100ml. As in the 3-month storm, a "hump" of elevated bacteria densities due to CSO can be observed moving downstream along the Mystic River starting at 6 hours after the peak of the storm. By 120 hours after the peak, the fecal coliform densities in Alewife Brook have returned to dry

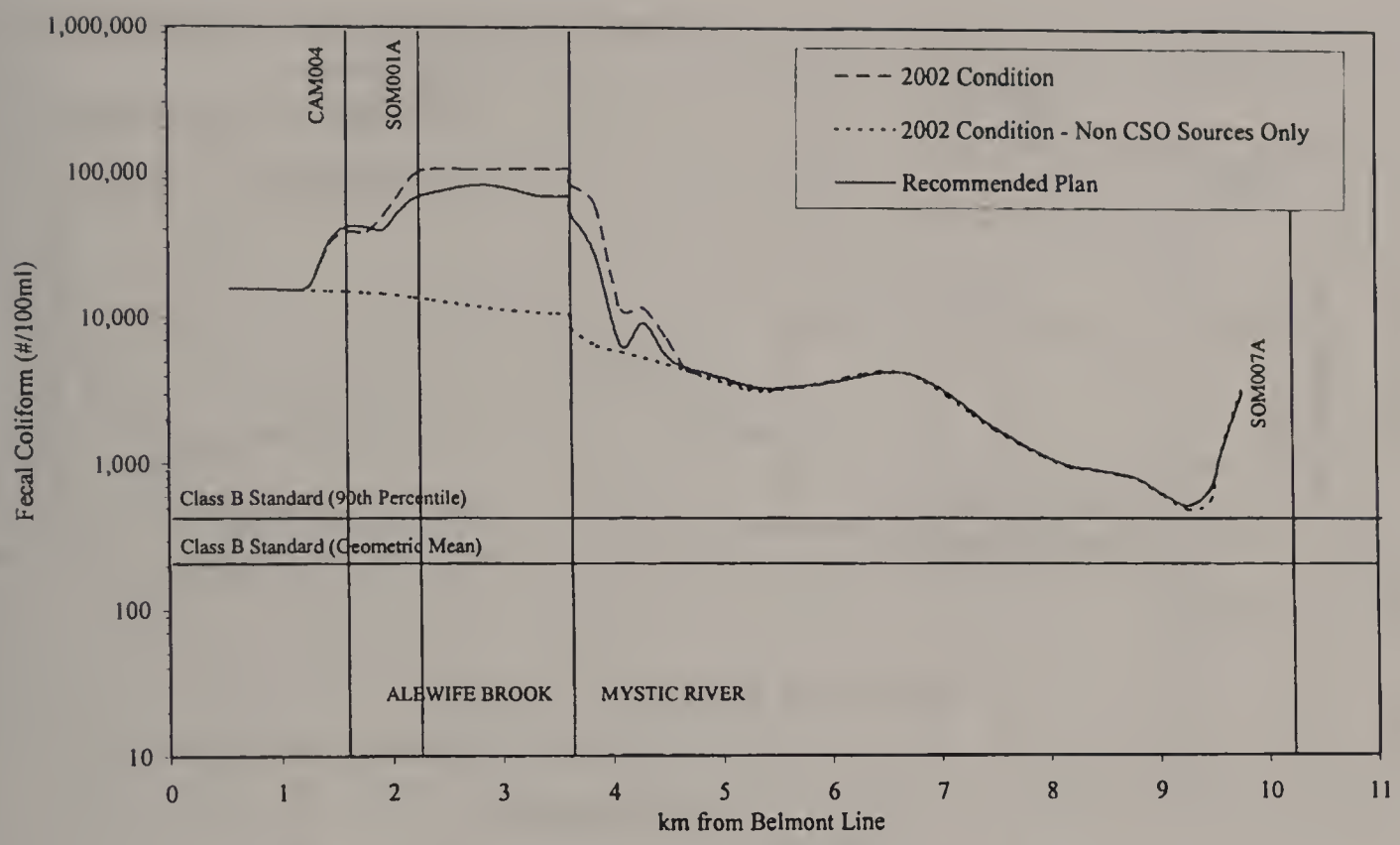


FIGURE 4-19. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
Peak of the 1-Year Storm

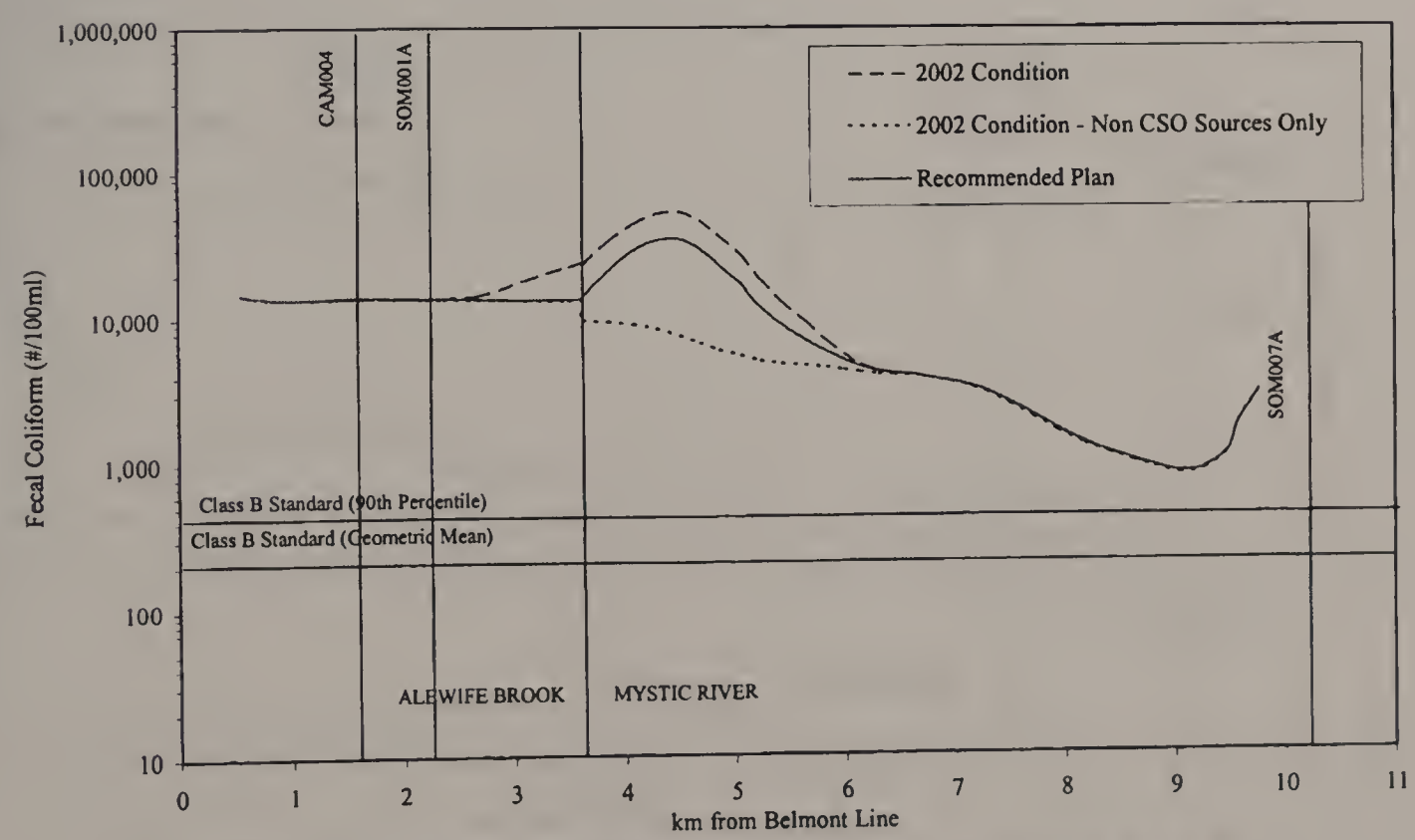


FIGURE 4-20. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
6 Hours After the Peak of the 1-Year Storm

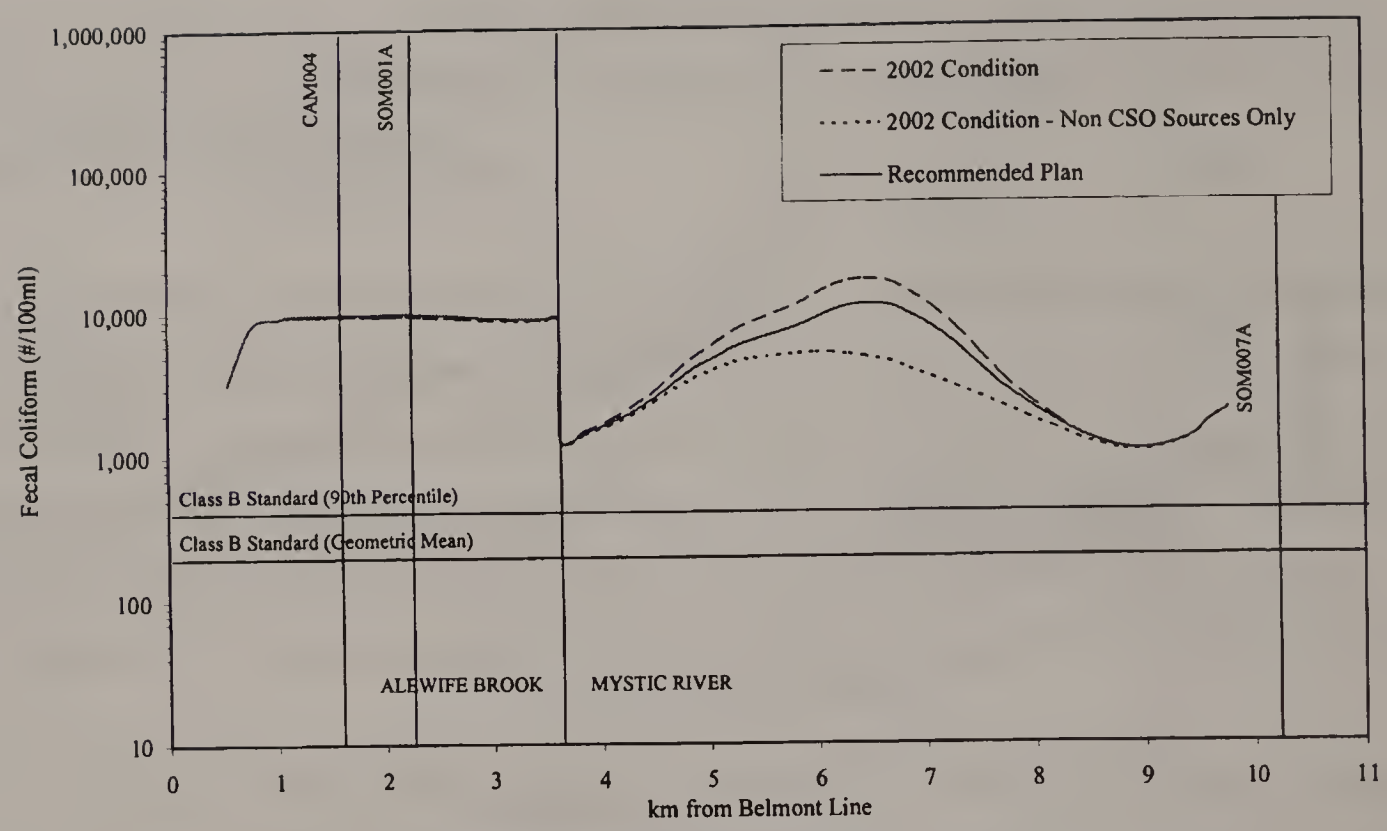


FIGURE 4-21. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
24 Hours After the Peak of the 1-Year Storm

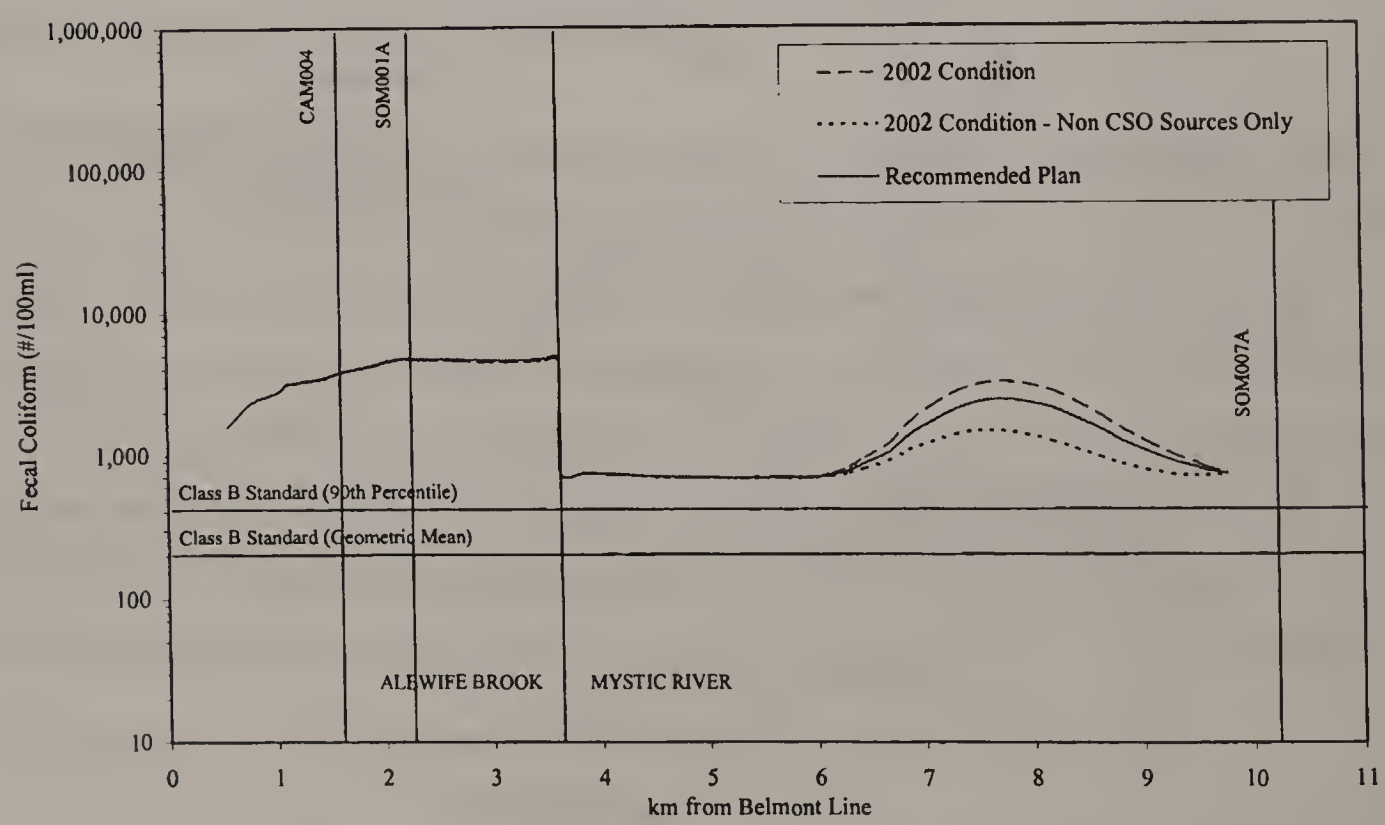


FIGURE 4-22. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
48 Hours After the Peak of the 1-Year Storm

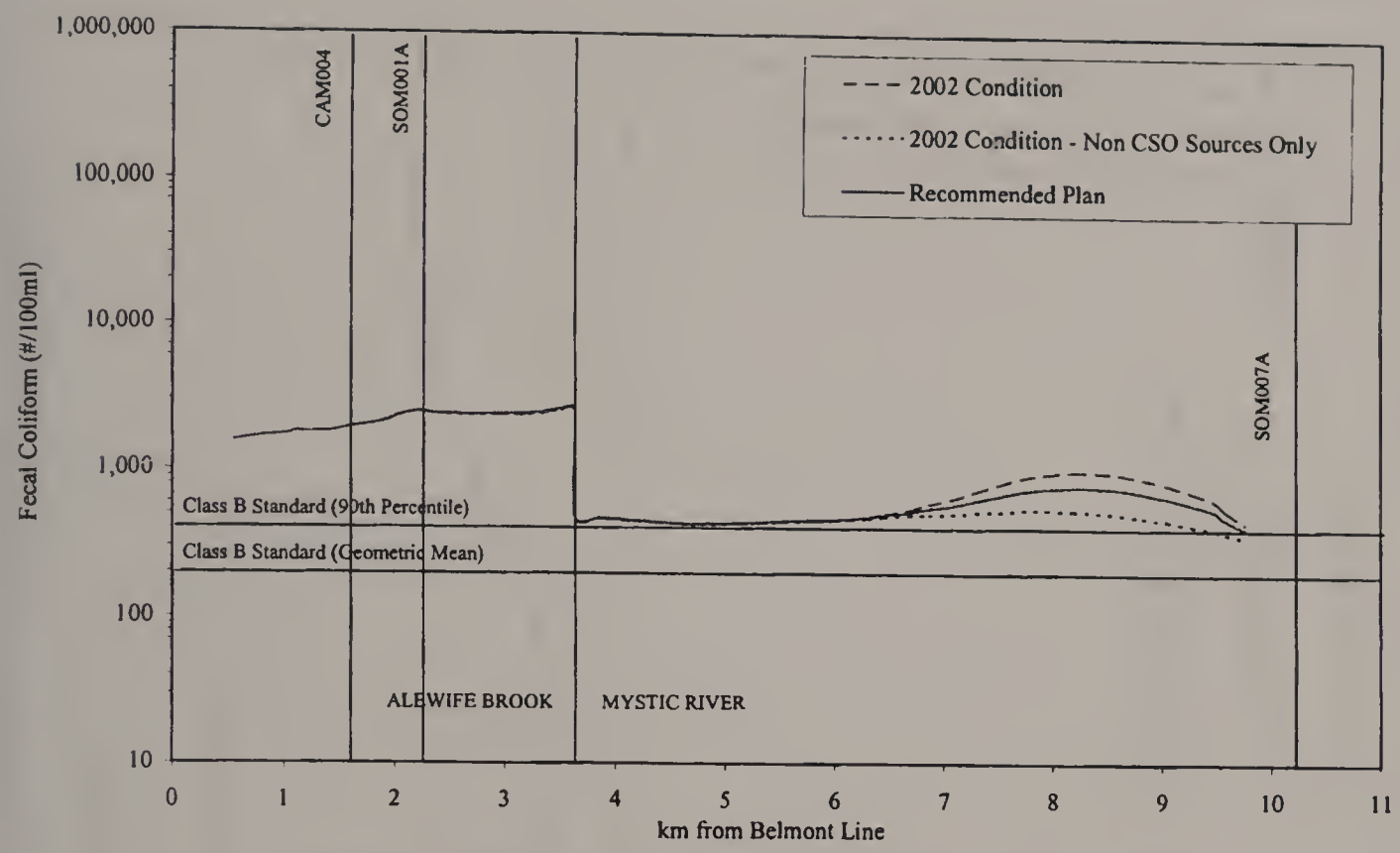


FIGURE 4-23. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
72 Hours After the Peak of the 1-Year Storm

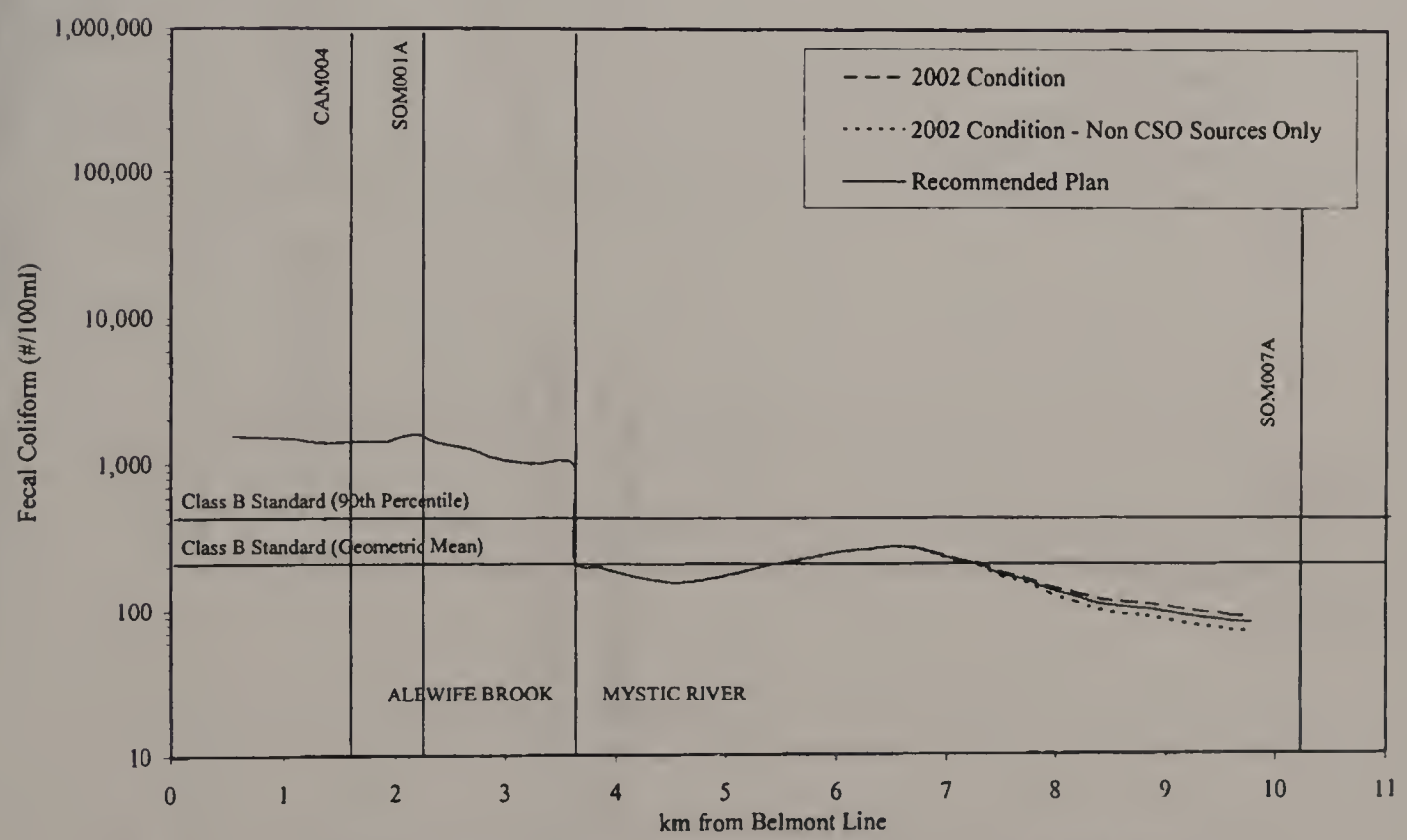


FIGURE 4-24. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
144 Hours After the Peak of the 1-Year Storm

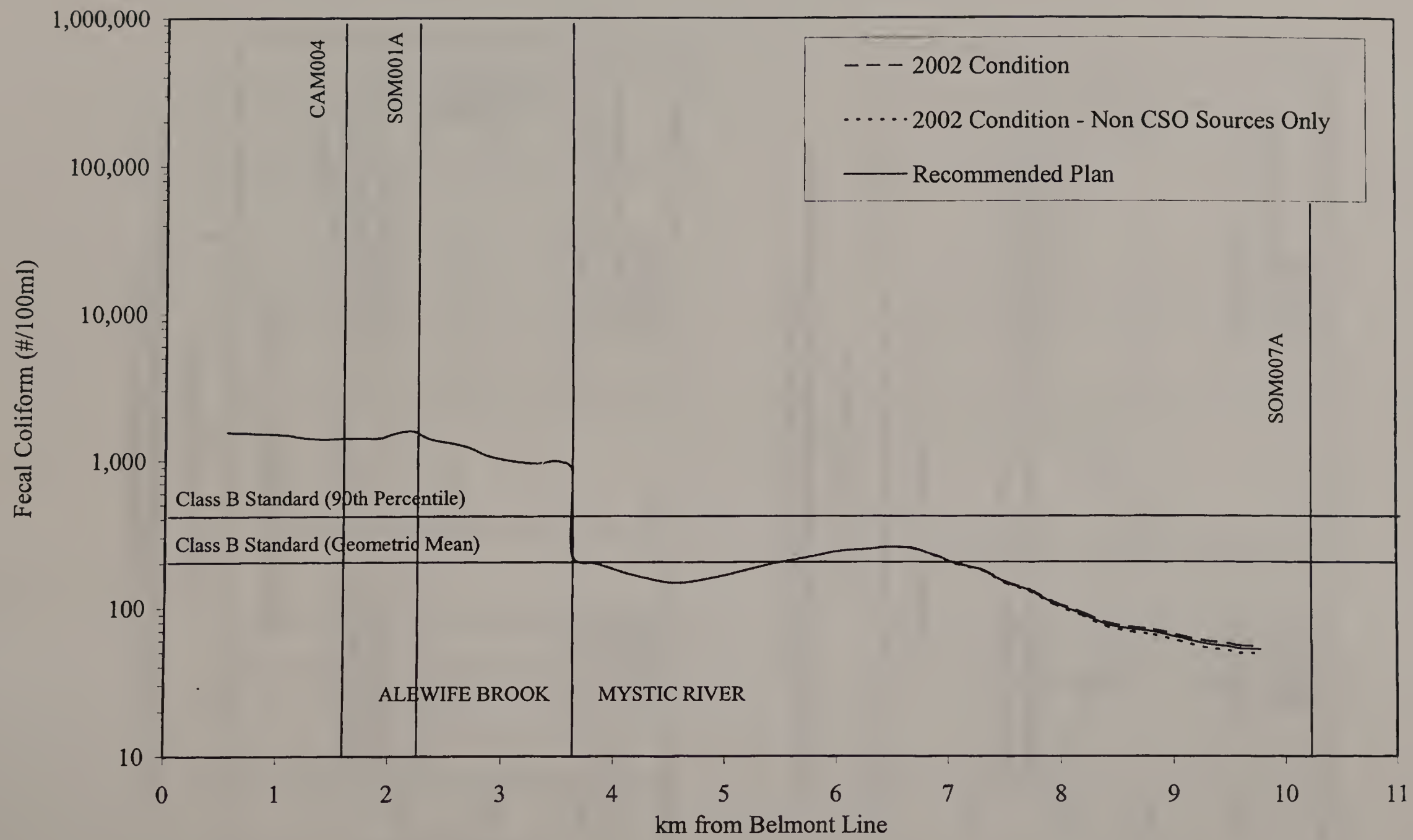


FIGURE 4-25. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
180 Hours After the Peak of the 1-Year Storm

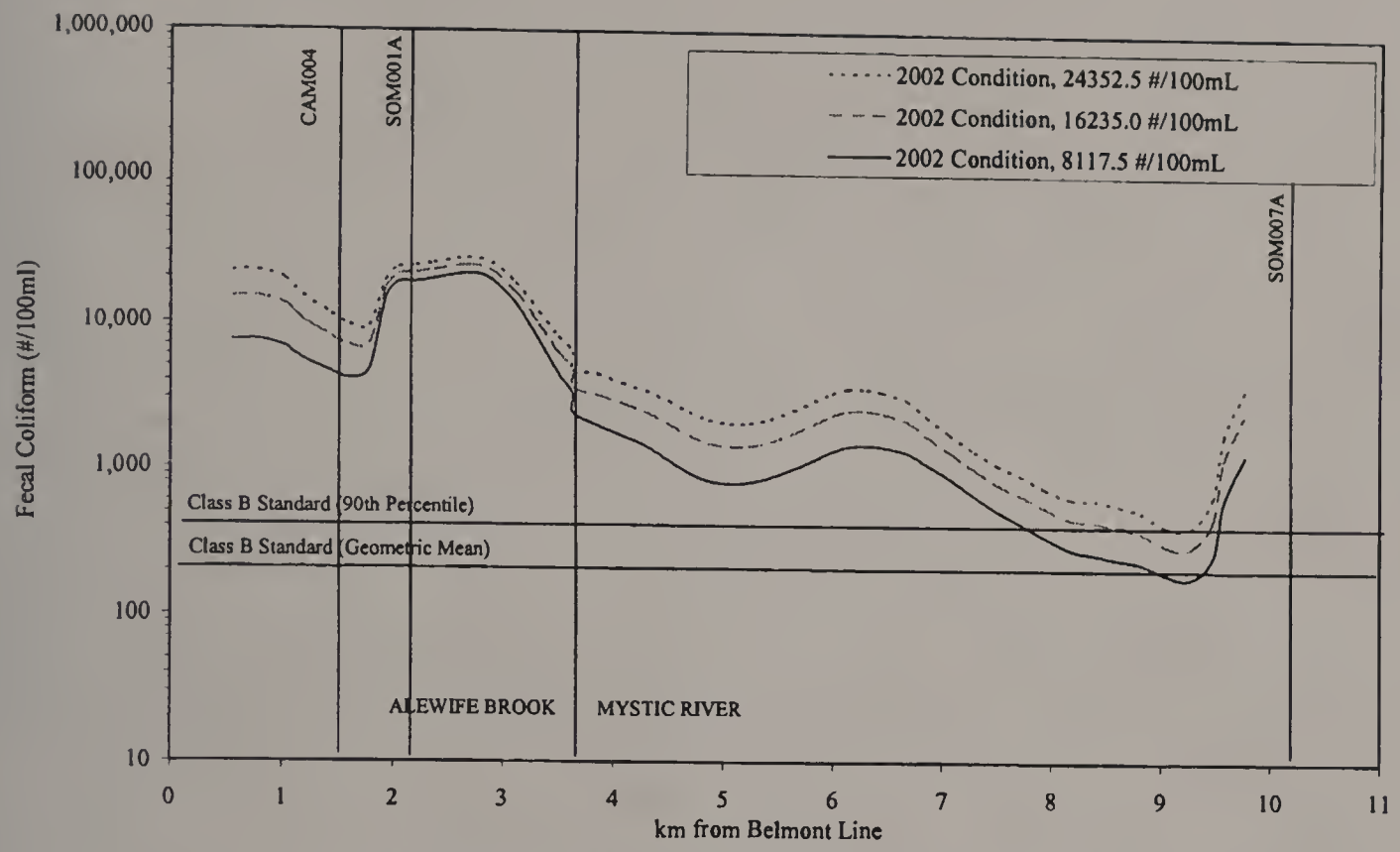


FIGURE 4-26. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
3 Month Storm - Peak of the Storm
Current Condition

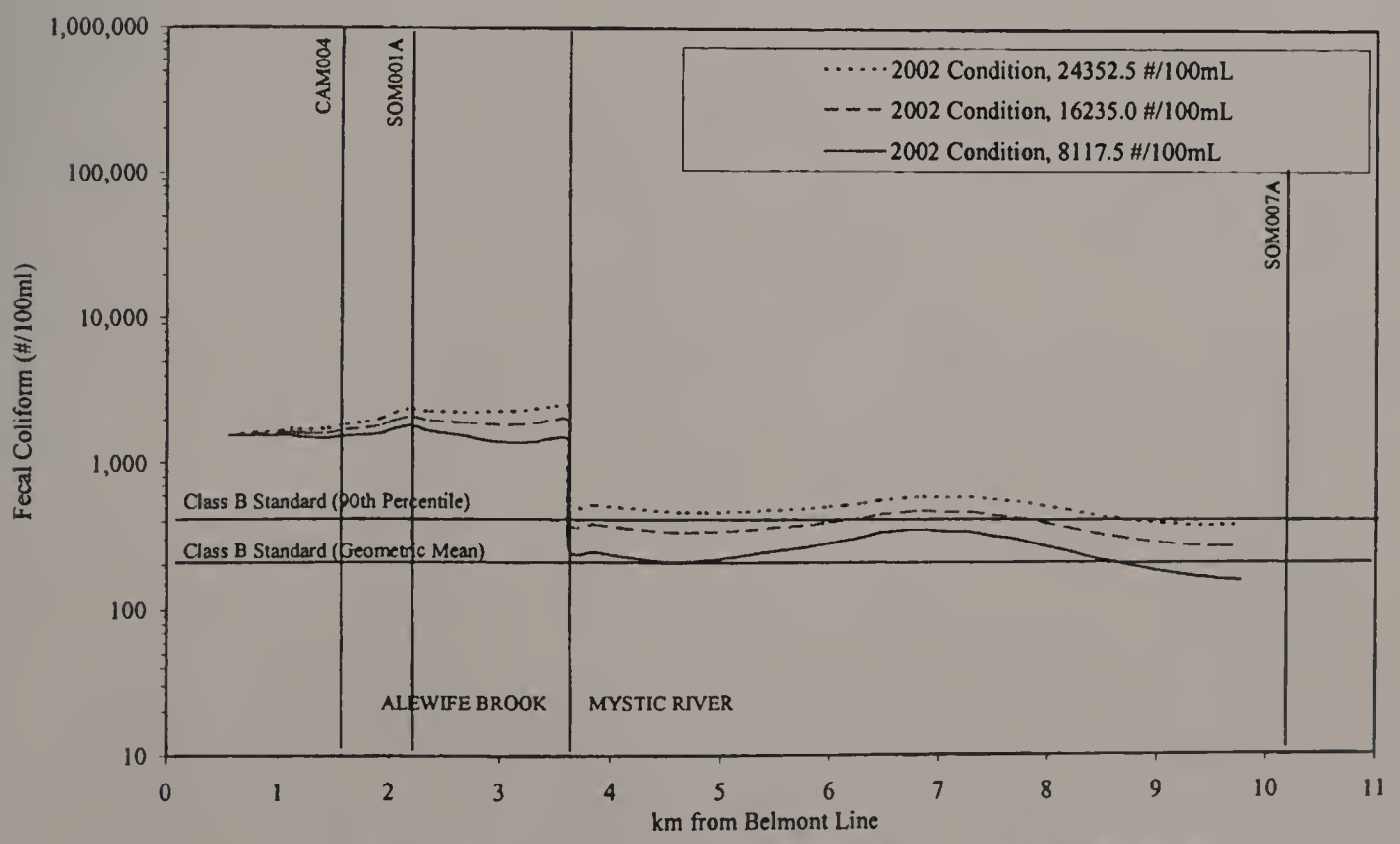


FIGURE 4-27. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
3 Month Storm - 84 Hours After the Peak of the Storm
Current Condition

the receiving water model for Alewife Brook and the Upper Mystic River, and served to enhance the understanding of baseline water quality conditions in these receiving waters. Data collected by others during the variance period were generally consistent with the data collected by MWRA. Model simulations with the re-calibrated water quality model of Alewife Brook and the Upper Mystic River also enhanced the understanding of baseline water quality conditions and the impact of non-CSO wet weather loads on the receiving waters. Based on these data and results of model simulations, the following general conclusions are drawn regarding baseline water quality conditions:

- Alewife Brook is significantly affected by dry weather sources of bacteria. The Upper Mystic River is also affected, but to a lesser degree. All of Alewife Brook is predicted to be in violation of the Class B standard in dry weather, while parts of the Upper Mystic River are predicted to be in violation of the Class B standard in dry weather.

- The duration of impact of CSOs on Alewife Brook is relatively short, compared to the extended duration of the impact of non-CSO wet and dry weather sources. The duration of impact of CSOs on the Upper Mystic River is longer than for Alewife Brook, but the magnitude of the impact is substantially lower.

- In the absence of CSO, fecal coliform bacteria densities in Alewife Brook are predicted to reach sustained levels on the order of 10,000 CFU/100ml for up to 48 hours after the peak of the 3-month storm. Under similar conditions, fecal coliform levels in the Upper Mystic River are predicted to range from approximately 700 to 7,000 CFU/100ml for up to 48 hours after the peak of the storm.

- Reducing the average fecal coliform density in stormwater by 50 percent reduced somewhat the magnitude of the non-CSO wet weather impacts, but did not significantly change the duration of exceedance of the Class B standard in wet weather.

Section Five

CHAPTER FIVE
DEVELOPMENT OF CSO CONTROL ALTERNATIVES

This chapter presents the methodology used in developing and evaluating CSO control alternatives for Alewife Brook; presents the baseline conditions from which the CSO control alternatives were developed; provides descriptions of the alternatives that were developed; and summarizes the performance of the range of alternatives.

METHODOLOGY

The range of CSO control alternatives presented herein was developed and evaluated at a master planning level of detail, consistent with the approach presented in the December 1994 CSO Conceptual Plan. The following section presents the specific methodology followed in developing and evaluating these alternatives.

Development of Alternatives

The process of developing CSO control alternatives for Alewife Brook generally involved identification of appropriate technologies, sizing the technologies for a range of CSO control levels based on predicted activation frequencies and volumes from the detailed SWMM model, and developing master planning-level layouts for the technologies.

Technologies to be Evaluated. Following the methodology used in the December 1994 CSO Conceptual Plan, the technologies to be evaluated were selected from the following overall list of CSO control technologies:

- Sewer Separation
- CSO Relocation
- Interceptor Relief/Pumping Station Modification
- CSO Consolidation

- In-System Storage
- Near Surface Storage/Treatment
- Deep Tunnel Storage
- Equivalent Primary Treatment
- Screening and Disinfection
- Floatables Control

For planning purposes, "equivalent primary treatment" was assumed to be a detention/treatment tank sized for a peak overflow rate of 4,500 gpd/sf, with fine screening, disinfection and dechlorination. It is recognized that emerging technologies such as chemically-enhanced primary treatment or ballasted flocculation may reduce the footprint and potentially the construction cost of providing equivalent primary treatment, although O&M costs may be higher. The detention/treatment tank, however, was assumed to serve as a reasonable place-holder for the range of treatment technologies for the purpose of cost/benefit analyses.

In the 1994 CSO Conceptual Plan, certain technologies and outfall consolidation options were eliminated from further consideration without developing more detailed cost and performance data, based on system knowledge, SWMM results and input from project workshops. Consistent with this approach, the following technologies were initially eliminated from further consideration:

- CSO relocation. A less-sensitive receiving-water segment is not located in the vicinity of Alewife Brook.
- Individual storage and/or treatment facilities for each outfall. Given the number of outfalls and limited space available along Alewife Brook, this alternative was not considered to be implementable.
- Deep tunnel storage. In the CSO Conceptual Plan, each of the regional deep tunnel storage alternatives that were developed assumed that local, near-surface controls would be provided for the Alewife Brook outfalls. Consistent with this approach, deep-rock tunnel storage alternatives were not evaluated further in this report.

- In-system storage. Based on preliminary modeling, it was apparent from surcharging of the interceptors and upstream piping systems that limited, if any, in-system storage would be available that was not already being used.

- Floatables control. Based on modeling of existing conditions, providing only floatables control, with no reduction in overflow frequency or volume, would not meet the regulatory intent of minimizing CSOs to the maximum extent feasible required for a B_{CSO} designation for Alewife Brook. Since this alternative would not meet the minimum likely water quality designation for the receiving water, it was not considered further.

Sizing Criteria. In order to establish the appropriate level of CSO control for Alewife Brook, it was necessary to assess both a range of CSO control technologies, as well as a range of design capacities for those technologies. Consistent with the EPA's National CSO Control Policy, the technologies selected for evaluation were sized for the following range of capacities:

- Total elimination of CSO (if feasible)
- Elimination of untreated CSO discharges in the typical year
- Allowing 1 to 4 untreated discharges in the typical year
- Allowing 4 to 7 untreated discharges in the typical year

For alternatives that involved a consolidation conduit, the specific range of alternatives developed included 0, 2 and 4 untreated overflows per year. For the targeted sewer separation alternatives that did not include a consolidation conduit, the range of control was expanded to 7 untreated overflows per year. Sizing criteria for individual technologies were based on the criteria presented in Appendix D of the October 1996 *Draft Combined Sewer Overflow Facilities Plan and Environmental Impact Report* (DEIR). Key criteria that relate to the sizing and/or cost of technologies are summarized in Table 5-1.

Siting/Layout Criteria. Consistent with the approach taken in the CSO Conceptual Plan, a cursory evaluation of siting potential was performed for each alternative. Consolidation conduits were routed to avoid passing under existing buildings, and storage/treatment tanks were located

TABLE 5-1. SIZING/DESIGN CRITERIA FOR CSO CONTROL TECHNOLOGIES

Technology	Parameter	Design Criteria
Storage Tanks	Maximum sidewater depth	15 ft.
	Vertical clearance between tank ceiling and maximum water surface	10.5 ft.
Primary Treatment Tanks	Peak overflow rate	4,500 gpd/sf
	Minimum detention time	15 minutes
	Minimum sidewater depth	12 ft.
	Vertical clearance between tank ceiling and maximum water surface	10.5 ft.
Consolidation Conduits	Peak flow conveyance capacity for consolidation to storage tank	Peak flow from design storm used for sizing storage
	Peak flow conveyance capacity for consolidation to treatment (primary or screening and disinfection)	Peak flow from the largest storm in the typical year
	Minimum Slope	0.001 ft./ft.
	Minimum diameter for tunnel boring machine with precast segmented liner	8 ft.
	Diameter range for microtunnel with jacked pipe	<8 ft.
Sewer Separation	Maximum reduction in inflow typically achievable[1]	80 percent

Notes: [1] If, on a site specific basis, a higher level of inflow removal is determined to be required to meet a specific CSO control goal, additional cost would be factored into the unit costs for separation.

in existing "open" areas, which may include parking lots and/or parklands. The *Atlas of the City of Cambridge*, taken from the City of Cambridge web site, was used as a background map for the locations of streets, buildings and open spaces. The background mapping information should be considered general, and has not been field-verified for this report. Siting issues and other non-monetary factors were qualitatively identified in a tabular format. Categories of siting and non-monetary issues considered for each alternative included the following:

- Construction-related siting impacts
- Long-term siting impacts
- Operations and Maintenance considerations

These categories were carried forward for use in the alternatives evaluation process.

Work Completed to Date. The scope of the CSO control alternatives described in this chapter includes work related to implementing the recommended CSO control plan as presented in the FEIR that has been completed to date, or is committed to being completed. These work items include the following:

- **Outfall Cleaning.** This work involved cleaning of the existing CAM004 outfall, as a short-term measure to improve the hydraulic capacity of the outfall.

- **Fresh Pond Parkway Sewer Separation/Hydraulic Capacity Improvement.** This work represents the first phase of the planned separation of the CAM004 tributary area in accordance with the FEIR recommended plan. Hydraulic evaluations conducted during preliminary design indicated that the existing combined sewer and storm drain trunks that run along Fresh Pond Parkway between the residential CAM004 tributary area and the CSO regulator associated with CAM004 had insufficient capacity to convey peak flows from extreme storm events (e.g. on the order of the 10 year storm). Since surcharging along Fresh Pond Parkway could potentially threaten the Fresh Pond water supply, it was determined that improvements to the conveyance capacity would be required, regardless of the final CSO control solution for outfall CAM004. This work is substantially complete.

- **Orchard Street Sewer Separation.** The Orchard Street area is located in the upstream reach of the CAM002 tributary area. Consistent with the FEIR recommended plan, work to separate this area was completed as an initial step in the complete separation of the CAM002 area. The separate sanitary and separate

stormwater pipes were connected to the existing combined sewer trunk tributary to the CAM002 regulator. The remaining upstream CAM002 separation work could not be completed until the hydraulic capacity of the main trunk was increased. Proposed work related to increasing the capacity of the main trunk has been indefinitely suspended, pending resolution of the updated recommended plan for Alewife Brook.

- **Floatables Control.** Various floatables control measures were identified for the outfalls along Alewife Brook in Cambridge during preliminary design. Based on the presumption that the updated recommended plan for Alewife Brook would not feature complete elimination of all outfalls, the floatables control projects are still considered part of the recommended plan.

- **New CAM004 Outfall/Stormwater Detention Constructed Wetland.** The existing CAM004 outfall was determined in preliminary design to have insufficient capacity to convey flows from storms greater than approximately the 2-year storm. Because of the potential consequences of upstream surcharging adjacent to the water supply at Fresh Pond, construction of the new outfall was considered necessary, regardless of the final CSO solution for outfall CAM004. In conjunction with the new outfall, a stormwater detention area was also required, in order to prevent an increase in the peak flow to Alewife Brook. The detention area is proposed to be in the form of a constructed wetland, and the proposed layout is described in detail in the May 2003 *Response To Comments on the Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook.* It should be noted that the storage and treatment alternatives considered for outfall CAM004 were sized for no greater than the flows from the largest storm in the typical year. Thus, even under a storage alternative, outfall conveyance capacity and the detention/wetland area would be required to relieve surcharging during more extreme storm events. The new CAM004 outfall and stormwater detention/wetland area are currently under design, with construction scheduled to begin by July 2005.

Costs associated with the above items are presented below.

Evaluation of Alternatives

The CSO control alternatives for Alewife Brook were evaluated based primarily on cost (capital, annual O&M, and net present value) and performance, with additional consideration given to non-monetary factors. The cost/performance analysis emphasized optimizing environmental benefit while ensuring a responsible use of public funds.

Cost. Costs developed for the various alternatives included capital costs, annual O&M costs, and net present value. Construction costs were developed from cost curves that were derived

from a range of sources including published cost equations, site-specific cost estimates developed during CSO facilities planning and recent design projects, and contractor's bid tabulations. Estimated annual O&M costs were developed from estimated hours of operation and staff levels, with allowances for chemicals and utilities. More detailed descriptions of the development of construction and O&M costs for each technology, along with relevant cost curves, are presented in the Appendix F. All construction costs were adjusted to an April, 2003 Boston-area Engineering News Record Construction Cost Index of 7717.

In accordance with the MWRA's LCCA policy, a 25 percent contingency and 20 percent allowance for engineering and construction management were added to the estimated construction cost to create the estimated capital cost. The one exception to this policy was for the estimated cost for sewer separation in the CAM004 area. A memorandum from SEA dated July 7, 1999, presented a preliminary design level estimate for the construction cost that included a 15 percent contingency (appropriate for preliminary design, according to the MWRA's LCCA policy). Net present value was computed using the MWRA's LCCA spreadsheet, based on a discount rate of 6 percent, an inflation rate of 2.5 percent, an effective discount rate of 3.40 percent, and a 30-year term.

The capital cost of all alternatives was adjusted to include the cost of the work already completed or committed to be completed, as described above. The costs of these items are summarized in Table 5-2. As indicated in Table 5-2, a total of $47,225,500 was added to the capital cost of each of the CSO control alternatives developed below to represent a total program cost for each alternative.

Performance. Performance was assessed in terms of reduction in annual CSO activation frequency and pollutant load. Storage alternatives were assumed to remove 100 percent of the load from the stored volumes, with no removal of load from volumes above the storage capacity. Primary treatment alternatives removed 100 percent of the load from volumes up to the storage capacity of the tank/consolidation conduit. For storms within the design overflow flow rate,

TABLE 5-2. SUMMARY OF COST OF WORK ITEMS ALREADY COMPLETED OR COMMITTED TO BE COMPLETED

Element	Total Cost
Outfall Cleaning (Contract 1)	$452,500
Fresh Pond Parkway (Contracts 2A and 2B)	$16,171,900
Orchard Street Separation (Contract 3)	$2,509,500
Engineering on Contracts 1 to 3	$6,994,400
Floatables Control (Contracts 4 and 5)	$3,725,000
New CAM004 Outfall (Contract 12)	$11,831,000
MWR003 Floatables Control	$300,000
Contingency (Contracts 4, 5 and 12)	$2,131,200
Engineering (Contracts 4, 5 and 12, and amendments)	$3,110,000
TOTAL	**$47,225,500**

effluent fecal coliform bacteria was assumed to be 200 counts/100 ml, with 40 percent TSS removal and 20 percent BOD removal. For storms exceeding the design flow rate, effluent fecal coliform bacteria was assumed to be 5,000 counts/100 ml, with 20 percent TSS removal and 5 percent BOD removal. Screening and disinfection alternatives were developed in conjunction with a consolidation conduit. It was assumed that 100 percent of the load was removed from volumes up to the storage capacity of the consolidation conduit. For storms within the design flow rate (the largest peak flow in the typical year), effluent fecal coliform bacteria was assumed to be 200 counts/100 ml, with 5 percent TSS removal and no BOD removal.

Pollutant loadings were established on an annual basis based on predicted annual volumes and average pollutant concentrations. With the exception of fecal coliform bacteria concentration in stormwater, the average pollutant concentrations for untreated CSO and stormwater were the same as were used for the CSO master planning and facilities planning programs. These values were based on sampling programs and research conducted in support of the CSO master planning program. As discussed in Chapter Four, the limited CSO sampling data collected in accordance with the variance conditions did not support changing the baseline average pollutant concentrations in CSO. The stormwater sampling conducted along Alewife Brook and the Upper

Mystic River between 1999 and 2002 to support the Variance indicated that the average stormwater bacteria concentration appeared to be substantially lower than the area-wide average concentration used in master planning and facilities planning. Baseline stormwater bacteria loadings were therefore computed using the average of the more recent data (16,235 CFU/100ml) in lieu of the average of the earlier data (30,250 CFU/100ml). The TSS and BOD values for the recent stormwater sampling were relatively close to the values used in master planning, so the master planning values for those parameters were used. The average values for bacteria, TSS and BOD for untreated CSO and stormwater are summarized in Table 5-3. Annual CSO and stormwater volumes were developed from the SWMM typical year simulations.

Cost/Performance Curves. A key aspect of the evaluation process was the development of cost/performance curves, which helped to identify the most cost-effective alternatives based on the "knee of the curve" analysis. The knee of the curve is the point at which further investment in CSO control yields diminishing returns in terms of pollutant load reduction. The curves were developed for CSO-only and total loads of fecal coliform bacteria, TSS, and BOD. In the case of Alewife Brook, "total" annual loads would include pollutant loads from CSO and stormwater discharges.

Non-Monetary Factors. Non-monetary factors were qualitatively assessed in a matrix format, by assigning relative ratings (+, 0, -) to each of the three categories of factors presented in the description of alternatives. The relative ratings were defined as follows:

- \+ Signified the alternative is better than others for the non-monetary factor rated.
- 0 Signified the alternative is not as good as some, but better than others for the non-monetary factor rated.
- \- Signified the alternative is less suited than others for the factor rated.

The ratings were summed, to provide an overall relative rating of the non-monetary impacts of the alternatives.

TABLE 5-3. AVERAGE POLLUTANT CONCENTRATIONS FOR CSO AND STORMWATER

	Fecal Coliform Bacteria (counts/100ml)	TSS (mg/l)	BOD (mg/l)
Untreated CSO[1]	538,000	140	78
Untreated Stormwater	16,235[2]	38[1]	20[1]

Notes: [1] Refer to the Draft System Master Plan Baseline Assessment, June 1994, for more detail on the source of the average pollutant concentration values.
[2] Refer to Chapter Four for a discussion of the average fecal coliform density in untreated stormwater.

BASELINE HYDRAULIC CONDITIONS

As described in Chapter Three, the existing SWMM model for the Alewife Brook tributary area was updated and recalibrated based on the latest available information on system configuration, as well as recent flow monitoring. This model was then used to define the baseline for the current CSO activation frequencies and volumes. Current conditions as well as CSO control alternatives performance were assessed on an annual basis.

A typical year of rainfall to be used to simulate annual performance was originally developed as part of the MWRA's CSO Conceptual Plan program. The typical year was intended to represent one full year of actual rainfall events that would approximate the long-term rainfall record. The year 1992 was selected as the base year from which a "typical" year would be developed because 1992 was relatively close to the 40-year average for total precipitation and distribution of storm size. To provide a better match to the actual 40-year averages, the 1992 rainfall record was adjusted by adding or removing certain storms. For example, compared to the long-term average, the year 1992 had fewer storms over 1 inch and more storms between 0.25 and 1 inch. Thus, two storms between 1 and 2 inches were added and 8 storms between 0.25 and 0.50 inches were removed from the 1992 base year. The typical year consists of 108 storms with a total precipitation of 43.1 inches.

A summary of the predicted annual overflow volumes by storm by outfall for the conditions prior to start of construction on Fresh Pond Parkway is presented in Table 5-4. Table 5-4 also summarizes the total annual volume and activation frequency by outfall.

As noted in Chapter Three, the metering data indicated that a restriction likely existed in the Alewife Brook Branch Sewer (ABBS) upstream of Massachusetts Avenue. Table 5-4 reflects the conditions with this apparent restriction in place. For sizing of CSO control alternatives, it was assumed that this restriction would be located and removed. Removal of the restriction, however, had very little impact on CSO activations or volumes. With the restriction removed, the total annual CSO volume was predicted to be reduced by less than one percent.

The alternatives were also evaluated assuming that the Phase I Bellis Circle Stormwater Management project is implemented. Additional stormwater detention projects identified under Phase II of the Bellis Circle work would potentially result in further reductions in annual CSO volume.

DEVELOPMENT OF ALTERNATIVES

Following the initial screening of technologies, the following alternatives were carried forward for further development and evaluation:

- CSO elimination by system-wide sewer separation
- Interceptor relief/pumping station modification
- Consolidated near-surface storage conduit
- Consolidated near-surface storage conduit with targeted sewer separation
- Consolidated near-surface storage facility with targeted sewer separation
- Consolidated near-surface primary treatment facility with targeted sewer separation
- Consolidated near-surface screening and disinfection facility with targeted sewer separation
- Targeted sewer separation

TABLE 5-4. SUMMARY OF CSO VOLUMES BY STORM IN TYPICAL YEAR - PRE-CONSTRUCTION CONDITIONS

STORM NO.	STORM EVENT	STORM DURATION (hour)	TOTAL RAIN DEPTH (inch)	AVERAGE INTENSITY (in/hr)	CSO VOLUME (MG) DISCHARGE TO ALEWIFE BROOK									
					ALT0 - BASE CASE									
					CAM001	CAM002	MWR003	CAM004 CS	CAM004 SD	CAM400	CAM401	CAM401B	SOM001A	TOTAL
1	1/4/1992	21.0	1.15	0.05					0.64			0.27		0.91
2	1/9/1992	4.8	0.16	0.03					0.02					0.02
3	1/14/1992	9.7	0.49	0.05					0.26			0.03		0.29
4	1/23/1992	16.3	1.36	0.08					0.75			0.24		0.99
5	2/14/1992	7.5	0.15	0.02					0.02					0.02
6	2/15/1992	11.2	0.87	0.08					0.45			0.03		0.48
7	2/18/1992	12.3	0.20	0.02					0.04					0.04
8	2/25/1992	17.0	0.83	0.05					0.35					0.35
9	3/6/1992	34.3	1.89	0.06					0.96			0.34		1.30
10	3/11/1992	12.5	0.97	0.08					0.50			0.12		0.62
11	3/19/1992	11.5	0.42	0.04					0.09					0.09
12	3/22/1992	9.8	0.27	0.03					0.04					0.04
13	3/26/1992	10.5	0.67	0.06					0.31					0.31
14	3/28/1992	18.8	0.42	0.02					0.09					0.09
15	4/11/1992	21.5	0.52	0.02					0.14					0.14
16	4/16/1992	30.3	1.02	0.03					0.35					0.35
17	4/22/1992	2.7	0.13	0.05					0.02					0.02
18	4/24/1992	20.5	0.73	0.04					0.27					0.27
19	5/2/1992	5.7	1.14	0.20		0.14			0.94	0.08	0.18	0.57	0.67	2.58
20	5/8/1992	10.0	0.27	0.03					0.07					0.07
21	5/31/1992	29.5	2.24	0.08					1.38	0.02	0.07	1.19	0.01	2.67
22	6/5/1992	17.5	1.34	0.08					0.73	0.02		0.34	0.31	1.40
23	6/20/1992	2.5	0.34	0.14					0.17					0.17
24	6/20/1992	0.5	0.11	0.21					0.02					0.02
25	6/24/1992	5.3	0.33	0.06					0.14					0.14
26	6/24/1992	10.0	0.23	0.02					0.05					0.05
27	7/6/1992	3.0	0.38	0.13					0.18					0.18
28	7/11/1992	0.7	0.22	0.30					0.10					0.10
29	7/14/1992	4.8	0.16	0.03					0.02					0.02
30	7/15/1992	16.3	0.50	0.03					0.20					0.20
31	7/23/1992	13.3	0.41	0.03					0.15					0.15
32	7/29/1992	0.8	0.20	0.27					0.08					0.08
33	7/31/1992	19.0	0.59	0.03					0.26			0.04		0.30
34	8/11/1992	10.8	0.87	0.08		0.16			0.74	0.08	0.19	0.41	1.10	2.68
35	8/14/1992	7.5	0.40	0.05					0.12					0.12
36	8/15/1992	38.7	1.10	0.03					0.33			0.05		0.38
37	8/17/1992	25.7	1.81	0.07		0.22		0.03	1.22	0.09	0.31	0.68	1.37	3.92
38	9/3/1992	12.5	1.19	0.10		0.04			0.70	0.03	0.02	0.38	0.65	1.82
39	9/8/1992	3.8	0.19	0.05					0.04					0.04

TABLE 5-4. SUMMARY OF CSO VOLUMES BY STORM IN TYPICAL YEAR - PRE-CONSTRUCTION CONDITIONS

STORM NO.	STORM EVENT	STORM DURATION (hour)	TOTAL RAIN DEPTH (inch)	AVERAGE INTENSITY (in/hr)	CSO VOLUME (MG) DISCHARGE TO ALEWIFE BROOK									
					ALT0 - BASE CASE									
					CAM001	CAM002	MWR003	CAM004 CS	CAM004 SD	CAM400	CAM401	CAM401B	SOM001A	TOTAL
40	9/9/1992	0.8	0.57	0.76		0.04			0.47	0.05		1.69	0.46	2.71
41	9/11/1992	7.5	0.38	0.05					0.15					0.15
42	9/19/1992	2.5	0.11	0.04					0.01					0.01
43	9/22/1992	22.2	2.79	0.13		0.49		0.05	2.38	0.20	0.86	1.25	2.62	7.85
44	9/26/1992	9.5	0.74	0.08					0.38			0.14		0.52
45	10/9/1992	2.5	0.26	0.10					0.11					0.11
46	10/10/1992	6.7	0.65	0.10					0.41			0.15	0.10	0.66
47	10/10/1992	5.5	0.47	0.09					0.30	0.01		0.09		0.40
48	10/11/1992	13.0	0.65	0.05					0.33			0.04		0.37
49	10/19/1992	2.5	0.11	0.04					0.01					0.01
50	10/21/1992	4.5	0.12	0.03					0.01					0.01
51	10/23/1992	3.3	1.18	0.36	0.01	0.48	0.06	0.24	1.40	0.22	1.11	0.67	2.60	6.79
52	10/24/1992	3.7	0.18	0.05					0.05					0.05
53	10/25/1992	7.5	0.20	0.03					0.01					0.01
54	11/3/1992	28.5	0.94	0.03					0.41			0.08		0.49
55	11/5/1992	12.8	0.31	0.02					0.08					0.08
56	11/21/1992	35.0	1.88	0.05					1.02			0.52		1.54
57	11/24/1992	26.7	0.46	0.02					0.04					0.04
58	11/26/1992	14.7	0.51	0.03					0.16					0.16
59	12/3/1992	8.2	0.82	0.10					0.46			0.10		0.56
60	12/11/1992	39.8	3.88	0.10					2.26			1.07		3.33
61	12/17/1992	14.8	0.58	0.04					0.20					0.20
62	12/29/1992	11.7	0.37	0.03					0.07					0.07
63	12/30/1992	10.3	0.44	0.04					0.12					0.12
TOTAL CSO VOLUME (MG)					**0.01**	**1.57**	**0.06**	**0.32**	**23.78**	**0.80**	**2.74**	**10.49**	**9.89**	**49.66**
CSO ACTIVATION FREQUENCY					**1**	**7**	**1**	**3**	**63**	**10**	**7**	**25**	**10**	

Each of these alternatives is described in the sections that follow. The general layout of the alternatives is presented in Figure 5-1. The descriptions of the alternatives include a tabulation of estimated costs and non-monetary factors. The alternatives are further evaluated and compared in Chapter Six.

CSO Elimination by System-wide Sewer Separation

This alternative would involve the complete sewer separation of the areas tributary to the remaining CSO outfalls to Alewife Brook, and would include separation of CSO regulators currently tributary to the Tannery Brook Drain in Somerville. To model this alternative, it was assumed that separation would achieve 80 percent inflow removal in the areas tributary to all outfalls except CAM401B and SOM01A. For CAM401B, the percentage of runoff entering the nominally separate sanitary system was assumed to be reduced from 17 to 7 percent. For the regulators tributary to SOM01A, it appeared that up to 95 percent inflow removal may be required in some areas to eliminate CSO discharge in the typical year. When the model was run under a scenario of 80 percent inflow removal at all regulators, and the overflows closed off, surcharging in the upstream collection system was predicted to increase over existing conditions under the 25-year storm. This run would indicate that greater than 80 percent inflow removal would have to be achieved on an area-wide basis in order to potentially close the CSO outfalls. The feasibility of achieving a sufficiently-high degree of inflow removal is not certain. Furthermore, the increase in the volume of separated stormwater discharged to the Alewife Brook increases the potential for Alewife Brook to flood under larger storm events.

Given these considerations, the total area of separation would be approximately 850 acres. A breakdown of tributary area and estimated capital cost by outfall is presented in Table 5-5. For the CAM002, CAM004 and CAM400 areas, the cost per acre was back-calculated from preliminary design estimates of the cost for sewer separation in those areas. The relatively lower unit cost for the CAM400 area reflects the fact that much of the separation in the CAM400 area would be limited to combined manhole separation. The relatively higher unit cost for the CAM002 area is traced to the need to replace the main combined sewer trunk line running along

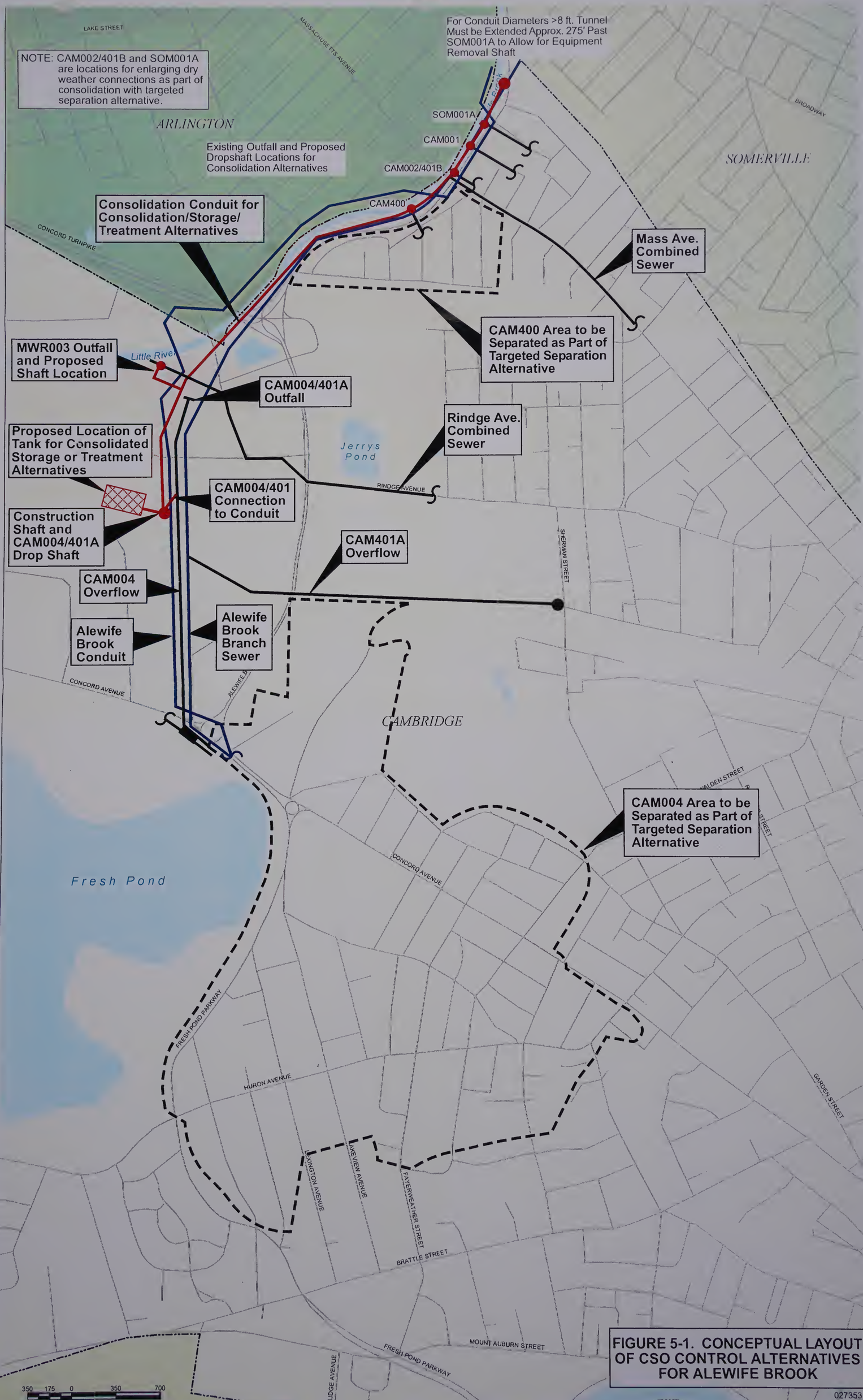


FIGURE 5-1. CONCEPTUAL LAYOUT OF CSO CONTROL ALTERNATIVES FOR ALEWIFE BROOK

Massachusetts Avenue from Alewife Brook Parkway to Porter Square, combined with the relatively small tributary area.

TABLE 5-5. TRIBUTARY AREAS OF CSO OUTFALLS TO ALEWIFE BROOK, AND ESTIMATED COST FOR COMPLETE SEWER SEPARATION

Outfall	Approximate Tributary Area (acres)	Estimated Capital Cost per Acre	Estimated Capital Cost for Complete Sewer Separation
CAM001	4	N/A(5)	$340,000
CAM002	89	$241,500	$21,494,000
CAM401A/B[1]	250	$127,500	$31,875,000
SOM01A	278	$127,500	$35,445,000
MWR003	N/A[2]	N/A[2]	N/A[2]
CAM401A/B New Outfall[3]			$16,567,000
Subtotal	**621**		**$105,721,000**
CAM004	214	$85,000	$18,190,000
CAM400	14	$85,000	$1,190,000
Common Costs for Work Completed/Committed[4]			$47,225,500
Subtotal	**228**		**$66,606,000**
Grand Totals	**849**		**$172,327,000**
Annual O&M Cost			**($19,100)**
Net Present Value			**$141,400,000**

Notes: (1) A clear distinction between the CAM401A and CAM401B tributary areas cannot be made at this time. The total tributary area to the CAM401A and B regulators is estimated at 250 acres.

(2) MWR003 is located directly on the Alewife Brook Conduit.

(3) It is assumed that a new outfall on the same order of magnitude and cost of the new CAM004 outfall would be required to carry additional wet weather flows from the CAM401 area to Alewife Brook.

(4) See Table 5-2 for breakdown of Common Costs.

(5) Due to the relatively small tributary area, costs for CAM001 separation were developed based on the length of streets to be separated.

For the CAM401A/B and SOM01A areas, an additional contingency was added to the average per-acre unit capital cost developed for separation in the upper areas tributary to outfall CAM004 to account for the complexity and shallow slopes of the existing collection system. It was also assumed that a major additional storm drain outfall would be required to convey the separated drainage from the CAM401 area to Alewife Brook under a complete separation scenario. For CAM001, the tributary area was considered to be too small to reliably use an average per-acre cost. The cost for CAM001 separation was developed based on a planning-level takeoff of the length of streets to be separated. These costs do not include measures to mitigate the impact of the additional stormwater flows resulting from sewer separation on Alewife Brook in terms of scour velocities and potential flooding.

As previously noted, all costs were adjusted to an ENR CCI of 7717. The negative O&M cost reflects an estimate of the savings in pumping costs at Alewife Brook Pumping Station and North Main Pumping Station resulting from the reduction in wet weather flow to the interceptor system. Table 5-6 presents the non-monetary factors for complete sewer separation. Additional discussion of the complete sewer separation alternative is presented in Chapter Six.

TABLE 5-6. NON-MONETARY FACTORS FOR COMPLETE SEWER SEPARATION

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Extensive construction-related impacts along most streets in the tributary areas. Total construction duration likely greater than 10 years. Feasibility of siting facilities to mitigate high flow rates and volumes on Alewife Brook uncertain.
Long-Term Siting Impacts	Potential long-term impact of multiple detention/retention facilities to mitigate impacts of high flows on Alewife Brook
O&M Considerations	Marginally reduced run time for pumps at Alewife Brook Pump Station and North Main Pump Station

Interceptor Relief/Pumping Station Modification

The Alewife Brook Pumping Station is located at the intersection of the Mystic Valley and Alewife Brook Parkways in Somerville. The pumping station features three 26 mgd pumps and one 12 mgd pump, along with a gravity bypass. The 26 mgd pumps and the gravity bypass discharge to the North Metropolitan Relief Sewer (NMRS), and the 12 mgd pump discharges to the North Metropolitan Trunk Sewer (NMTS). The NMTS and NMRS are tributary to the Chelsea Creek Headworks.

In the MWRA's November 1994 *Technical Memorandum on Intermediate Projects*, alternatives for potentially reducing CSO discharges along Alewife Brook by increasing the pumping capacity at Alewife Brook Pumping Station were developed and evaluated. Specific alternatives considered included:

- Increasing pumping capacity by changing the operation of the existing pumps
- Increasing pumping capacity by installing new pumps
- Increasing the size of the wetwell

At the time of that report, the maximum pumping capacity utilized during wet weather was estimated at 58 mgd. Records of actual flow rate pumped were not available at that time. Modeling at that time indicated that brief flooding was predicted in the pump discharge chamber during the 1-year storm. Removal of stop logs on various downstream siphon chambers was predicted to reduce, but not eliminate, the flooding, and had minimal effect on CSOs to Alewife Brook. The report concluded that increasing the pumping capacity at Alewife Brook Pumping Station would not be appropriate due to the lack of additional flow capacity in the downstream NMTS and NMRS.

As described in Chapter Three, flow records are now available that indicate that the maximum pumping capacity at Alewife Brook Pumping Station is approximately 75 mgd. In addition, the updated model does not predict flooding in the pumping station discharge chamber in the 1-year storm.

The first step in the re-evaluation of Alewife Brook Pumping Station capacity was to simulate the pumping station in SWMM as a free discharge. This simulation would provide an indication of the maximum peak flow that could be delivered to the pumping station by the Alewife Brook Conduit and Alewife Brook Branch Sewer during the typical year, as well as the impact of that conveyance capacity on upstream CSOs. Under the free discharge conditions, the peak flow to the pumping station in the typical year was 103 mgd. In total, nine storms in the typical year generated flows greater than the existing maximum pumping capacity of 75 mgd. The free discharge had relatively little impact on CSO frequency and volume. Activation frequencies decreased by no more than two per year, and the total annual volume discharged was reduced by approximately 12 percent.

The pumping station was then simulated with a peak pumping capacity of 110 mgd. To maximize potential performance at the higher pumping rate, it made sense to evaluate increasing the pumping capacity with an alternative that included separation of CAM004 and CAM400, as well as enlarging the dry weather flow connections at CAM002, CAM401B and SOM01A. Under this alternative, with the peak pumping capacity of 110 mgd, the peak hydraulic grade line in the NMRS downstream of the pumping station surcharged to within approximately two feet of grade. Compared with a similar run (separation at CAM004 and CAM400; enlarging the dry weather flow connections at CAM002, CAM401B and SOM01A) but with the existing pumping capacity of 75 mgd, the 110 mgd pumping capacity reduced the annual CSO volume by 12 percent, while outfall activation frequencies were generally reduced by one or two per year.

Discussions with MWRA operations staff at the Alewife Brook Pumping Station indicated that the current pump operating levels are set to provide sufficient suction head on the pumps. Increasing the pumping capacity to 110 mgd could potentially require construction of a new wetwell to maintain the appropriate suction head. Relief of a portion of the downstream NMRS would also be required to reduce the peak surcharge elevation.

From these results, the following conclusions were drawn:

- Providing relief of the Alewife Brook Conduit and/or Alewife Brook Branch Sewer would not be appropriate. As indicated by the free discharge simulation, the existing interceptors are capable of delivering 103 mgd to the pumping station. Pumping at a rate of 110 mgd, however, would result in an unacceptably high hydraulic grade line in the NMRS downstream of the pumping station. Thus, there is insufficient downstream capacity to carry flows greater than the peak flow that could currently be delivered to the pumping station by the existing interceptors.

- Increasing the pumping capacity to 110 mgd, in conjunction with separation of CAM004 and CAM400, and enlarging the dry weather flow connections at CAM002, CAM401B and SOM01A, resulted in only marginally improved CSO reduction compared with a similar alternative with the pumping station at its existing capacity of 75 mgd. The 110 mgd pumping capacity also resulted in an unacceptably-high peak hydraulic grade line downstream of the pumping station.

- Providing relief of the NMRS downstream of the pumping station, in combination with either relief of the Alewife Brook Conduit and/or Alewife Brook Branch Sewer or increased pumping capacity would still provide only marginally improved CSO reduction in comparison with alternatives that do not include increased conveyance capacity.

For these reasons, increasing the conveyance capacity of the Alewife Brook interceptor system and Alewife Brook Pumping Station is not recommended, and these alternatives were not developed further.

Consolidated Near-Surface Storage Conduit

This alternative would involve constructing an approximately 4,500 lf conduit from a location adjacent to the Alewife MBTA Station to the vicinity of outfall SOM01A. Based on the required diameter, it was assumed that the conduit would be constructed using a tunnel boring machine with a pre-cast segmented tunnel liner. A near-surface connecting conduit would run from the CAM004/401 outfall to the downstream shaft near the Alewife MBTA Station. The tunnel would be mined from this shaft. The consolidation conduit would extend approximately 300 feet north of outfall SOM01A, into an area where sufficient space would potentially be available for locating the upstream shaft for removal of the tunnel boring machine and installation of the odor control equipment. The contents of the storage conduit would be emptied by pumping to the Alewife Brook Conduit at the end of a storm via pump-out facilities provided at the downstream shaft, near the MBTA station. Preliminary routing of the consolidation conduit was intended to

avoid passing under existing buildings. Alternative conduit sizes were developed to allow 0, 2, or 4 overflows in the typical year. Table 5-7 presents the size and estimated capital costs, annual O&M costs and net present value for the storage conduit alternatives, while Table 5-8 summarizes the non-monetary factors. The capital costs in Table 5-7 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-7. SIZE AND ESTIMATED COST FOR CONSOLIDATED STORAGE CONDUIT ALTERNATIVES

Level of Control Based on Typical Year	Consolidation Conduit Size		Estimated Costs		
	Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 overflows	4,500	17.5	$145,100,000	$225,000	$139,500,000
2 overflows	4,500	12.5	$115,000,000	$225,000	$111,400,000
4 overflows	4,500	10.5	$113,400,000	$225,000	$109,900,000

TABLE 5-8. NON-MONETARY FACTORS FOR CONSOLIDATED STORAGE CONDUIT ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at main mining shaft near MBTA station for duration of construction, and periodic disruptions at equipment removal shaft, dropshaft and diversion structure locations along Alewife Brook.
Long-Term Siting Impacts	Relatively small pump-out facility at downstream end may fit below grade. Odor control facility at upstream end likely to be above grade. Public opposition to siting is likely, and identification of suitable sites will be difficult.
O&M Considerations	Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required

Consolidated Near-surface Storage Tank

This alternative would involve constructing a storage tank in the vicinity of the Alewife MBTA station with a consolidation conduit running south from outfall SOM01A. A connecting conduit would direct the flow from the CAM004/401 outfall directly to the storage facility. The contents of the storage tank would be returned by pumping to the Alewife Brook Conduit after the end of the storm. For planning purposes, the consolidation conduit was sized to convey the peak flow from the design storm that served as the basis for sizing the storage facilities. For example, to provide zero overflows in the typical year, the consolidation conduit was sized to convey the peak flow from the largest storm in the typical year, and the combined storage capacity of the consolidation conduit and storage tank was set to equal the total overflow volume from the largest storm in the typical year.

Based on the required diameter of the consolidation conduit, it was assumed the conduit would be constructed by microtunneling/jacked pipe. Since the upstream shaft at SOM01A would not need to be as large as for a larger-diameter tunnel boring machine/precast segmented liner system, it was assumed that the consolidation conduit would end just north of outfall SOM01A. The storage tank would be configured to take advantage of available storage capacity in the consolidation conduit.

Alternative facility sizes were developed to allow 0, 2, or 4 overflows in the typical year. Table 5-9 presents the size and estimated capital costs, annual O&M costs and net present value for the storage conduit/tank alternatives, while Table 5-10 summarizes the non-monetary factors.

The capital costs in Table 5-9 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-9. SIZE AND ESTIMATED COST FOR CONSOLIDATED STORAGE TANK ALTERNATIVES

Level of Control Based on Typical Year	Storage Tank Size (MG)	Consolidation Conduit Size		Estimated Costs		
		Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 overflows	7.0	4,180	6	$141,600,000	$757,000	$145,100,000
2 overflows	3.0	4,180	6	$112,600,000	$522,000	$114,100,000
4 overflows	2.3	4,180	4.5	$104,600,000	$522,000	$106,500,000

TABLE 5-10. NON-MONETARY FACTORS FOR CONSOLIDATED STORAGE TANK ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, and at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook.
Long-Term Siting Impacts	Tank and pumping equipment would be below grade, but tank odor control facility likely to be above grade. Odor control facility at upstream end of conduit likely to be above grade. Public opposition to siting of tank and upstream odor control facility is likely, and identification of a suitable site will be difficult.
O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required

Consolidated Near-surface Primary Treatment Facility

This alternative would be similar to the consolidation near-surface storage alternative, except that the downstream tank would be sized to provide equivalent primary treatment, and would

include fine screening, disinfection and dechlorination equipment. The facility would be similar in concept to the MWRA's Cottage Farm and Prison Point CSO Facilities. The primary treatment tank would be configured to take advantage of storage capacity in the consolidation conduit before discharging. It is anticipated that the discharge from the facility would require pumping to Alewife Brook, and the volume of flow remaining in the tank and consolidation conduit at the end of a storm would be pumped back to the Alewife Brook Conduit. Alternative facility sizes were developed such that 0, 2, or 4 storms in the typical year would result in flows that would exceed the design overflow rate of 4,500 gpd/sf. The consolidation conduit for all alternatives was sized to convey the largest storm in the typical year. Where flows would exceed the design overflow rate, a reduced level of treatment was assumed.

Table 5-11 presents the size and estimated capital costs, annual O&M costs and net present value for the consolidation-to-primary treatment alternatives, while Table 5-12 summarizes the non-monetary factors. The capital costs in Table 5-11 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-11. SIZE AND ESTIMATED COST FOR CONSOLIDATED PRIMARY TREATMENT FACILITY ALTERNATIVES

Level of Control Based on Typical Year	Primary Treatment Tank Size (MG)	Consolidation Conduit Size		Estimated Costs		
		Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 overflows[1]	2.1	4,180	6	$157,200,000	$499,000	$155,300,000
2 overflows[1]	2.0	4,180	6	$128,100,000	$499,000	$128,200,000

Notes: [1] Overflow in this context means occasions when the peak flow rate through the facility exceeds the design overflow rate of 4,500 gpd/sf. These flows would receive a level of treatment considered to be "less than primary treatment".

TABLE 5-12. NON-MONETARY FACTORS FOR CONSOLIDATED PRIMARY TREATMENT FACILITY ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, and at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook.
Long-Term Siting Impacts	Primary treatment tank and pumping equipment would be below grade, but facility odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end of consolidation conduit likely to be above grade. Periodic chemical deliveries required. Public opposition to siting is likely, and identification of a suitable site will be difficult
O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.

Consolidated Near-Surface Screening and Disinfection Facility

This alternative would be similar to the consolidated near-surface primary treatment alternative, except that the downstream tank would be replaced with a screening and disinfection/ dechlorination facility. The facility would be similar to the MWRA's Somerville Marginal, Fox Point and Commercial Point CSO facilities. The screening and disinfection/dechlorination facility would be configured to take advantage of storage capacity in the consolidation conduit before discharging. It is anticipated that the discharge from the facility would require pumping to Alewife Brook, and the volume of flow remaining in the consolidation conduit at the end of a storm would be pumped back to the Alewife Brook Conduit. This alternative was only sized for the largest storm in the typical year. Table 5-13 presents the size and estimated capital cost, annual O&M cost and net present value for the consolidation-to-screening/disinfection alternative, while Table 5-14 summarizes the non-monetary factors. The capital costs in Table 5-13 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-13. SIZE AND ESTIMATED COST FOR CONSOLIDATED SCREENING AND DISINFECTION FACILITY ALTERNATIVE

Level of Control Based on Typical Year	Peak Design Flow (mgd)	Consolidation Conduit Size		Estimated Costs		
		Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 untreated overflows	117	4,180	7	$108,300,000	$342,000	$107,000,000

TABLE 5-14. NON-MONETARY FACTORS FOR CONSOLIDATED SCREENING AND DISINFECTION FACILITY ALTERNATIVE

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at screening/disinfection facility site near MBTA station, and at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook
Long-Term Siting Impacts	Screening and pumping equipment would be below grade, but odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end likely to be above grade. Periodic chemical deliveries required. Public opposition to siting is likely, and identification of a suitable site will be difficult.
O&M Considerations	Cleanup of screening facility required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.

Consolidated Near-Surface Storage Conduit with Targeted Sewer Separation

In the CSO Conceptual Plan, it was recognized that separation of the area tributary to outfall CAM004 would significantly reduce the volume of flow tributary to the interceptor system. This reduction in flow would reduce the peak hydraulic grade line in the interceptors, which would, in turn, result in reduced CSO discharges at other outfalls along the Alewife Brook. Separation of

outfall CAM004 would therefore significantly reduce the size of a consolidation conduit required to capture the CSOs along Alewife Brook. In the current analysis, certain other relatively low-cost projects have been identified that, in conjunction with separation of CAM004, would further reduce the volume of CSO to be captured in a consolidation conduit. These projects include:

- Separation of common manholes upstream of outfall CAM400, and implementation of the recommended system optimization plan (SOP). The original SOP called for routing a separate storm drain around the regulator, and raising the overflow weir. Based on information from the city of Cambridge, it appears that what was indicated to be a separate drain on the Cambridge 100-scale sewer maps was, in fact, cross-connected with the sanitary system via common manholes. The recommended SOP could not, therefore, be implemented until the upstream common manholes were separated.

- Enlarging the local connections between the interceptor system and the regulators associated with outfalls CAM002, CAM401B and SOM01A. SWMM analyses indicated that a number of overflows are caused at these locations due to the restricted capacity of the local connections. In each case, increasing the size of the connections would involve less than 50 feet of new pipe. The work would, however, be complicated by the location of these regulators, at or near the intersection of Massachusetts Avenue and Route 16.

- Providing a hydraulic relief gate at outfall MWR003. This gate would minimize discharges from outfall MWR003 in smaller storms, and would open to allow additional relief during larger storms to protect upstream hydraulic grade lines.

With the targeted separation and other pipe work noted above, this alternative would be similar to the consolidation/storage conduit alternative, except that the diameter of the consolidation/storage conduit required to meet the range of CSO controls would be reduced. This alternative was sized for 0, 2 and 4 overflows in the typical year. For the 0 overflows per year alternative, it is assumed that the conduit would be installed by tunnel boring machine with precast segmented tunnel liner. For the 2 and 4 overflows per year alternatives, it was assumed that the conduit would be installed by microtunneling/jacked pipe. In the CSO Conceptual Plan, this alternative was developed for control of the 1-year storm, only.

Table 5-15 presents the size and estimated capital costs, annual O&M costs and net present value for the storage conduit with targeted sewer separation alternatives, while Table 5-16 summarizes

TABLE 5-15. SIZE AND ESTIMATED COST FOR CONSOLIDATED STORAGE CONDUIT WITH TARGETED SEWER SEPARATION ALTERNATIVES

Level of Control Based on Typical Year	Consolidation Conduit Size		Estimated Costs		
	Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 overflows	4,500	11.5	$145,300,000	$223,000	$139,600,000
2 overflows	4,180	6.5	$111,600,000	$223,000	$108,200,000
4 overflows	4,180	3.5	$98,000,000	$223,000	$95,300,000

TABLE 5-16. NON-MONETARY FACTORS FOR CONSOLIDATED STORAGE CONDUIT WITH TARGETED SEWER SEARATION ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	For 0 overflow/yr alternative, construction-related disruptions at main mining shaft site near MBTA station for the duration of the construction, and periodic disruption at the equipment removal shaft. For the 2 and 4 overflow/yr alternatives, construction-related disruptions at the jacking and receiving shafts. For all alternatives, periodic disruptions at dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.
Long-Term Siting Impacts	Pumping equipment would be below grade, but odor control facility at upstream end likely to be above grade. Public opposition to siting of shafts and odor control facility is likely, and identification of suitable sites will be difficult. Detention basin or constructed wetland area required to attenuate peak stormwater flows.
O&M Considerations	Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.

the non-monetary factors. The capital costs in Table 5-15 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

Consolidated Near-Surface Storage Tank with Targeted Sewer Separation

This alternative was similar to the consolidated storage tank alternative, except that the volume of CSO to be captured would be reduced by the targeted sewer separation upstream of outfalls CAM004 and CAM400, and piping changes at the CAM002, CAM401B and SOM01A regulators described above. In the current analysis, it was found that the size of the tanks required to provide the 2 and 4 overflows per year levels of control would be less than 0.4 million gallons. It did not seem reasonable to construct such small tanks at the end of theconsolidation/storage conduit, so these alternatives were not evaluated further. Table 5-17 presents the size and estimated capital costs, annual O&M costs and net present value for the storage conduit/tank with partial sewer separation alternative, while Table 5-18 summarizes the non-monetary factors. The capital costs in Table 5-17 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-17. SIZE AND ESTIMATED COST FOR CONSOLIDATED STORAGE FACILITY WITH TARGETED SEWER SEPARATION ALTERNATIVE

Level of Control Based on Typical Year	Storage Tank Size (MG)	Consolidation Conduit Size		Estimated Costs		
		Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 overflows	2.1	4,180	7	$140,400,000	$480,000	$139,300,000

Consolidated Near-surface Primary Treatment Facility with Targeted Sewer Separation

This alternative would have been similar to the consolidated primary treatment facility alternative, except that the quantity of CSO to be treated and the design flow rate would be reduced by the targeted sewer separation upstream of outfalls CAM004 and CAM400, and piping changes at the CAM002 and CAM401B regulators described above. However, in sizing this alternative, it was found that the total volume of storage available in the primary treatment tanks plus the consolidation conduit would have been greater than the total CSO volume to be

treated (note that the primary treatment tanks are sized based on a peak overflow rate and a minimum side water depth). Therefore, this alternative was not developed further. This alternative was similarly not developed for the CSO Conceptual Plan.

TABLE 5-18. NON-MONETARY FACTORS FOR CONSOLIDATED STORAGE FACILITY WITH TARGETED SEWER SEPARATION ALTERNATIVE

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.
Long-Term Siting Impacts	Tank and pumping equipment would be below grade, but tank odor control facility likely to be above grade. Odor control facility at upstream end likely to be above grade. Identification of a site for the storage tank will be difficult, and public opposition to siting is likely. Detention basin/constructed wetland required to attenuate peak stormwater flows.
O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.

Consolidated Near-Surface Screening and Disinfection Facility with Targeted Sewer Separation

This alternative would be similar to the consolidated screening and disinfection facility alternative, except that the quantity of CSO to be treated and the design flow rate would be reduced by the targeted sewer separation upstream of outfalls CAM004 and CAM400, and piping changes at the CAM002, CAM401B and SOM01A regulators described above. This alternative was only sized for the largest storm in the typical year. Table 5-19 presents the size and estimated capital cost, annual O&M cost and net present value for the consolidation-to-screening/disinfection alternative, while Table 5-20 summarizes the non-monetary factors. The capital costs in Table 5-19 include the $47.2 million cost for work already completed or committed, that will be common to all alternatives.

TABLE 5-19. SIZE AND ESTIMATED COST FOR CONSOLIDATED SCREENING AND DISINFECTION FACILITY WITH TARGETED SEWER SEPARATION ALTERNATIVES

Level of Control Based on Typical Year	Peak Design Flow (mgd)	Consolidation Conduit Size		Estimated Costs		
		Length (lf)	Diameter (ft)	Capital	Annual O&M	Net Present Value
0 untreated overflows	164	4,180	8	$130,000,000	$336,000	$127,600,000

TABLE 5-20. NON-MONETARY FACTORS FOR CONSOLIDATED SCREENING AND DISINFECTION FACILITY WITH TARGETED SEWER SEPARATION ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related disruptions at screening/disinfection facility site near MBTA station, at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.
Long-Term Siting Impacts	Screening and pumping equipment would be below grade, but odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end likely to be above grade. Identification of a site for the screening and disinfection facility will be difficult, and public opposition to siting is likely. Detention basin/constructed wetland required to attenuate peak stormwater flows.
O&M Considerations	Cleanup of screening facility required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required

Targeted Sewer Separation

The intent of the targeted sewer separation alternatives was to focus the separation work in areas where sewer separation would have the most benefit, then to assess whether removal of inflow from those areas would also benefit less-active outfalls by reducing the hydraulic grade line in the interceptor system. Targeted separation alternatives were therefore initially focused on the

most active outfalls. CSO activation frequencies and volumes for Alewife Brook CSOs prior to the start of construction of Contracts 2A and 2B along Fresh Pond Parkway are summarized in Table 5-21 (along with other alternatives that are discussed below).

As part of the reassessment of CSO control alternatives for Alewife Brook, targeted sewer separation alternatives were evaluated for outfalls CAM001, CAM002, CAM004, CAM400, CAM401B and SOM01A. Outfall MWR003 is a side-outlet relief directly off of the Alewife Brook Conduit, and does not have a regulator-specific upstream tributary area. Outfall CAM401A is affected by backwater from the Rindge Avenue combined sewer, which has a tributary area of over 250 acres. Separation of this area was not evaluated, for the following reasons:

- CSO discharges to Alewife Brook could be cost-effectively minimized without separation of outfall CAM401A.
- Due to the size and complexity of the CAM401A tributary area, the cost of separation would be very high.
- The existing CAM401A outfall may not have sufficient capacity to discharge increased stormwater flows associated with sewer separation. Increasing the hydraulic capacity of the outfall would add further cost to this alternative.
- Given the level of control predicted to be achieved under the revised recommended plan, providing a higher level of control at outfall CAM401A through additional targeted sewer separation was judged not to be cost-effective.

As described above, the combination of targeted sewer separation upstream of outfalls CAM004 and CAM400, and minor piping changes at the CAM002, CAM401B and SOM01A regulators was assessed in conjunction with outfall consolidation alternatives as a means for reducing the size and cost of the consolidation alternatives. In developing targeted sewer separation alternatives that would be considered in lieu of an outfall consolidation to storage or treatment alternative, an additional array of targeted separation and/or local piping changes were considered.

The range of targeted separation alternatives evaluated are described below.

TABLE 5-21. COMPARISON OF TARGETED SEWER SEPARATION ALTERNATIVES

	Existing Conditions Prior to Contract 2A/2B Construction		Separation and Closure of Outfall CAM004		Separation and Closure of Outfall CAM004, with Relief of Interceptor Connections		Separation and Closure of Outfall CAM004 and CAM400, with Relief of Interceptor Connections		Targeted Sewer Separation Alternative A(3)		Targeted Sewer Separation Alternative B(4)		Targeted Sewer Separation Alt. B with Complete Separation of CAM002		Targeted Sewer Separation Alt. A with CAM001 Separation and Closure		Targeted Sewer Separation Alt. A with Reductio9n of CAM401B Inflow to 10%	
Capital Cost(1)			$71.8M		$72.0M		$73.2M		$73.7M		$82.5M		$95.8M		$75.0M		N/A(2)	
Annual O&M			($4,100)		($5,200)		($5,200)		($5,200)		($7,500)		($9,400)		($5,200)			
Net Present Value			$67.1M		$71.9M		$73.1M		$68.8M		$77.1M		$89.4M		$74.9M			
Outfall	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)
CAM001	1	0.01	0	0	5	0.17	5	0.17	5	0.19	4	0.13	3	0.01	0	0	5	0.14
CAM002	7	1.57	8	1.26	5	0.78	4	0.79	4	0.69	1	0.07	0	0.00	4	0.68	4	0.66
MWR003	1	0.06	1	0.02	5	0.80	5	0.86	5	0.98	4	0.62	3	0.41	5	0.98	4	0.65
CAM004	63	24.1`	0	0.00	0	0	0	0	0	0.00	0	0.00	0	0.00	0	0	0	0.00
CAM400	10	0.80	10	0.65	11	1.23	0	0	0	0/0	0	0.0	0	0.0	0	0	0	0.0
CAM401A	7	2.74	8	3.13	5	2.34	5	2.33	5	1.61	4	1.29	3	1.14	5	1.59	5	1.61
CAM401B	25	10.5	24	9.91	8	1.97	7	1.93	7	2.15	8	1.69	6	1.24	8	2.51	8	1.33
SOM01A	10	9.89	10	9.52	4	1.77	3	1.47	3	1.67	4	1.20	3	1.76	4	1.61	4	1.49
Totals	**63**	**49.7**	**24**	**24.5**	**11**	**9.08**	**7**	**7.6**	**7**	**7.3**	**8**	**5.0**	**6**	**3.7**	**8**	**7.4**	**8**	**5.9**

Notes: (1) Capital costs based on ENR CCI 7717, and include $47.2 million in costs already spent/committed.

(2) Capital cost not estimated, due to undefined scope of separation required to achieve degree of inflow removal evaluated.

(3) **Targeted Separation Alternative A** included the following elements:

- Complete sewer separation upstream of CAM004, including the hydraulic relief gate at outfall MWR003.
- Separation of common manholes upstream of outfall CAM400, and closure of the outfall as a CSO.
- Enlarging the local connections between the interceptor system and the regulators associated with outfalls CAM002, CAM401B and SOM01A.
- Relief of the connection between the ABBS and the ABC where the Rindge Avenue combined sewer connects to the ABBS. This alternative reduced the peak hydraulic grade line in the Rindge Avenue combined sewer, which in turn reduced overflows at the CAM401 regulator on Sherman Street near Pemberton Street.

(4) **Targeted Separation Alternative B** included all of the elements of Targeted Separation Alternative A, with the addition of the following:

- Separation of the area tributary to the Massachusetts Avenue combined sewer upstream of Cedar Street, and installation of a new drain between Cedar Street and Alewife Brook.

Targeted Separation and Closure of Outfall CAM004. Development of the targeted sewer separation alternatives was an iterative process, and the first iteration to be evaluated was separation of the CAM004 tributary area only. Outfall CAM004 was evaluated first, because it was the most active outfall and had the largest annual CSO volume of all of the Alewife Brook CSOs. The predicted results of separation of just outfall CAM004 are presented in Table 5-21. As indicated in Table 5-21, separation of outfall CAM004 was predicted to reduce the total annual volume of CSO to Alewife Brook by about half, compared with conditions prior to Contract 2A/2B construction. While virtually all of the volume reduction would occur at CAM004, separation of this area would remove a significant quantity of wet weather flow from the interceptors along Alewife Brook. The benefit of this reduction in flow would not be realized, however, without increasing the size of the dry weather flow connections at certain regulators, in particular the regulators associated with outfalls CAM002, CAM401B and SOM01A (see below). This alternative also included providing a hydraulic relief gate at outfall MWR003. With the proposed closure of outfall CAM004, outfall MWR003 would become the most upstream relief point along the Alewife Brook system. It was determined that in storms larger than those that occurred in the typical year, additional relief was required at outfall MWR003 to protect upstream hydraulic grade lines. The gate at MWR003 would function as a weir during the typical year, and would be designed to open to provide extra relief based on a high-level signal at an upstream location along the interceptor. As the upstream water surface dropped, the gate would be signaled to close. This gate would therefore not affect performance during the typical year.

Targeted Separation and Closure of Outfall CAM004, with Relief of Interceptor Connections at Regulators Associated with Outfalls CAM002, CAM401B, and SOM01A. Based on review of hydraulic profiles of the "Targeted Separation and Closure of Outfall CAM004" alternative, it was apparent that further CSO control could be achieved by relieving the interceptor connections at certain regulators. The greatest

headloss between the regulators and the interceptor system was noted at the regulators associated with outfalls CAM002, CAM401B and SOM01A. As indicated in Table 5-21, the incremental capital cost of including the interceptor connection relief projects would be $0.1 Million, while the maximum annual activation frequency would be reduced from 24 to 11, and the annual volume reduced from 24.5 MG to 9.1 MG.

Targeted Separation and Closure of Outfalls CAM004 and CAM400, with Relief of Interceptor Connections at Regulators Associated with Outfalls CAM002, CAM401B, and SOM01A. Based on the results of the previous targeted sewer separation alternative, it was noted that the outfall with the highest remaining activation frequency was outfall CAM400 (11 activations per year). The tributary area to outfall CAM400 was a relatively small area, served by separate sanitary pipes and storm drains in an over/under configuration with common manholes. If the common manholes were separated, it was determined to be feasible to close this outfall as a CSO outfall (the outfall pipe would remain as a separate storm drain). The common manhole separation work would not increase the peak flow of stormwater to Alewife Brook, since the capacity of the existing outfall was not going to be increased. As indicated in Table 5-21, the incremental capital cost of this alternative would be $1.2 million. The maximum annual activation frequency would be reduced from 11 to 7, and the annual CSO volume would be reduced from 9.1 to 7.6 MG.

Targeted Separation and Closure of Outfalls CAM004 and CAM400, with Relief of Interceptor Connections at Regulators Associated with Outfalls CAM002, CAM401B, and SOM01A, and Relief of Rindge Avenue Siphon (Targeted Separation Alternative A). The previous alternative was then expanded to include relief of the connection between the ABBS and the ABC where the Rindge Avenue combined sewer connects to the ABBS. This alternative reduced the peak hydraulic grade line in the Rindge Avenue combined sewer, which in turn reduced overflows at the CAM401 regulator on Sherman Street near Pemberton Street. As indicated in Table 5-21, the incremental cost of this alternative would be $0.4 million. The maximum activation frequency would remain at 7 per year, and the annual CSO volume would be reduced

from 7.8 to 7.3 MG. This alternative was designated "Targeted Sewer Separation Alternative A".

Targeted Separation Alternative B. This alternative included all of the elements of Targeted Separation Alternative A, with the addition of the following:

- Separation of the area tributary to the Massachusetts Avenue combined sewer upstream of Cedar Street, and installation of a new drain between Cedar Street and Alewife Brook.

This alternative would have an incremental cost above Alternative A of $8.8 million, and would reduce the annual CSO volume by 2.2 MG.

Targeted Separation Alternative A with Separation of CAM001. This alternative included all of the elements of Targeted Separation Alternative A, plus separation and closure of outfall CAM001. As indicated in Table 5-21, the incremental cost of this alternative above Alternative A would be $1.4 million. The maximum activation frequency would increase to 8, and the total annual volume would increase to 7.4 MG. Sewer separation and closure of this outfall would not, therefore, result in an incremental improvement in water quality in Alewife Brook.

Targeted Separation Alternative A with Separation of CAM401B. Outfall CAM401B relieves what is nominally indicated on the City of Cambridge 100-scale sewer maps as a separate sanitary sewer that runs up Massachusetts Avenue, turns onto Cottage Street, then continues into the CAM401A/Rindge Avenue tributary area. Meter data indicate that approximately 17 percent of the rainfall that lands on this tributary area gets into the pipe tributary to outfall CAM401B as inflow, suggesting a significant degree of cross-connection with the combined system in that area. The effect of reducing the level of inflow from 17 to 10 percent in conjunction with Targeted Sewer Separation Alternative A was assessed. As indicated in Table 5-21, the estimated cost of this alternative was not developed due to uncertainty over the scope of separation work required to achieve the reduction in inflow. In addition, if the MWRA were required to

achieve a higher level of control than predicted with Alternative A, then Targeted Separation Alternative B appeared to be a better-defined and likely more cost-effective means to achieve a higher level of control than CAM401B inflow reduction.

Targeted Separation Alternative B with Complete Separation of Outfall CAM002. Targeted sewer separation alternative B, as described above, included separation of the area tributary to the Massachusetts Avenue combined sewer upstream of Cedar Street, and installation of a new drain between Cedar Street and Alewife Brook. Under alternative B, the Cedar Street tributary area and the Massachusetts Avenue combined sewer between Cedar Street and regulator RE021 would remain combined. Another alternative was considered that was similar to alternative B, except that it included complete separation of the CAM002 tributary area. The cost and performance of this alternative are presented in Table 5-21.

Targeted Separation of Outfall SOM01A. Outfall SOM01A provides relief of the Tannery Brook Drain, which runs from Alewife Brook through Davis Square in Somerville. The City of Somerville is currently studying the Tannery Brook Drain, in part to assess the feasibility of separating the drain. A total of five upstream regulators discharge CSO to the Tannery Brook Drain. At the downstream end, the drain is connected through an orifice opening to the Alewife Brook Conduit, with a transverse weir controlling overflow to Alewife Brook. The upstream regulators are therefore internal regulators, tributary to the downstream regulator at the Alewife Brook Conduit. One scenario for separation of the Tannery Brook Drain would be to separate the areas tributary to the upstream regulators, eliminate any direct sanitary connections to the Tannery Brook Drain, close the orifice connection to the interceptor, and convert the system to a separate storm drain.

Preliminary model runs were conducted to assess the degree of inflow removal that would be required to allow closure of the upstream regulators. Under existing conditions, the most active upstream regulator on the Tannery Brook Drain is predicted to activate 37 times in the typical year, and the total annual CSO volume tributary to the Tannery Brook

Drain from the upstream regulators is 16.4 million gallons. If sewer separation could remove 80 percent of the inflow tributary to the upstream regulators, the maximum upstream regulator activation frequency would be reduced to 10 and the annual volume to 1.8 million gallons. At 95 percent inflow removal, the activation frequency would be 6, with a volume of 0.7 million gallons. Based on detailed sewer separation studies in Boston, it appears that 80 percent inflow removal through sewer separation is generally achievable, but 95 percent inflow removal would likely require difficult and expensive separation of internal building plumbing.

The studies being conducted in Somerville, and subsequent studies that are being considered, may identify other alternatives for addressing the flows from the Tannery Brook Drain. Alternatives that may be proposed by the City of Somerville that would convert the Tannery Brook Drain to a separate storm drain, or otherwise reduce either the volume discharged at outfall SOM01A or the peak flow tributary to the Alewife Brook Conduit, would be consistent with the MWRA's currently-recommended plan for Alewife Brook. For this reason, and given the uncertainty over the cost and scope of separation required to convert the Tannery Brook Drain to a separate storm drain, this alternative was not carried forward for this report.

The cost and the performance in terms of activation frequency and volume of the targeted separation alternatives are presented in Table 5-21. The capital costs in Table 5-21 include the $47.2 million cost for work already completed or committed that will be common to all alternatives. Based on an assessment of incremental costs and benefits, four of the alternatives presented in Table 5-21 were carried forward to the more detailed cost/performance assessments:

- Targeted Separation and Closure of Outfall CAM004
- Targeted Separation Alternative A
- Targeted Separation Alternative B
- Targeted Separation Alternative B with Complete Separation of CAM002

Table 5-22 presents data for total annual activations by outfall, and annual activations greater than 0.05 MG by outfall, for Targeted Separation Alternatives A and B. The

point to be made with this table is that predicted annual activation frequency is not necessarily the best indicator of performance for these targeted separation alternatives, since the predicted volume associated with a number of these remaining activations is relatively small. Table 5-23 presents non-monetary factors for the targeted sewer separation alternatives.

TABLE 5-22. SUMMARY OF PERFORMANCE OF TARGETED SEWER SEPARATION ALTERNATIVES

Outfall	Pre-Construction Conditions		Alternative A		Alternative B	
	Total Annual Activa-tions	Annual Activa-tions >0.05 MG	Total Annual Activa-tions	Annual Activa-tions >0.05 MG	Total Annual Activa-tions	Annual Activa-tions >0.05 MG
CAM001	1	0	5	1	4	1
CAM002	7	5	4	3	1	1
MWR003	1	1	5	4	4	3
CAM004cs	3	2	0	0	0	0
CAM004sd	63	48	0	0	0	0
CAM400	10	5	0	0	0	0
CAM401	8	6	5	3	3	3
CAM401B	25	20	7	5	8	5
SOM01A	10	9	3	3	3	2
Total Annual Vol, MG	49.7		7.4		5.0	

TABLE 5-23. NON-MONETARY FACTORS FOR TARGETED SEWER SEPARATION ALTERNATIVES

Non-Monetary Factor	Comment
Short-Term Siting Impacts	Construction-related impacts along most streets in the tributary areas to be separated (CAM004, CAM400, CAM002 and/or SOM01A, depending on the alternative)
Long-Term Siting Impacts	Detention basin/constructed wetland required to attenuate peak stormwater flows.
O&M Considerations	Marginally reduced run time for pumps at Alewife Brook Pump Station and North Main Pump Station

PERFORMANCE OF ALTERNATIVES

The performance of the range of CSO control alternatives was assessed in terms of annual pollutant load removed. Reductions in loadings of fecal coliform bacteria, TSS, and BOD were computed based on discharge volumes and average pollutant concentrations. Table 5-24 presents the annual CSO pollutant load reductions for the range of alternatives, along with the CSO load reduced as a percentage of the baseline CSO load, and the total pollutant load reduced as a percent of the baseline total load. For Alewife Brook, the total load computations include separate stormwater discharges, and factor in the increase in stormwater discharge associated with the sewer separation alternatives. As indicated in Table 5-24, for CSO loads, annual fecal coliform bacteria reductions range from 80 to 100 percent, while TSS and BOD load reductions range from approximately 49 to 100 percent. On a total load basis, including stormwater loads, annual fecal coliform bacteria reductions range from 32 to 63 percent, while TSS and BOD load reductions range from negative values (net increase in load) to 17 percent.

Cost/performance relationships and the effect of the reduction in pollutant loads on attainment of water quality standards in Alewife Brook are discussed in Chapter Six.

TABLE 5-24 - SUMMARY OF POLLUTANT LOAD REMOVED FOR CSO CONTROL ALTERNATIVES

Number	ALTERNATIVE DESCRIPTION	ANNUAL CSO LOAD REDUCTIONS			CSO LOAD REDUCED AS A PERCENT OF BASELINE CSO LOAD			TOTAL LOAD REDUCED AS A PERCENT OF BASELINE TOTAL LOAD		
		Fecal Coliform Bacteria, counts X 10^{12}	Total Suspended Solids, lbs.	Biochemical Oxygen Demand, lbs.	Fecal Coliform Bacteria %	Total Suspended Solids %	Biochemical Oxygen Demand %	Fecal Coliform Bacteria %	Total Suspended Solids %	Biochemical Oxygen Demand %
1	Consolidated Storage Conduit, 0 overflows/yr	1,012	58,030	32,331	100%	100%	100%	62%	16%	17%
2	Consolidated Storage Conduit, 2 overflows/yr	882	50,964	28,187	87%	88%	87%	54%	14%	15%
3	Consolidated Storage Conduit, 4 overflows/yr	833	48,280	26,613	82%	83%	82%	51%	13%	14%
4	Consolidation Conduit to Storage Tank, 0 overflows/yr	1,012	58,030	32,331	100%	100%	100%	62%	16%	17%
5	Consolidation Conduit to Storage Tank, 2 overflows/yr	871	50,343	27,823	86%	87%	86%	54%	14%	14%
6	Consolidation Conduit to Storage Tank, 4 overflows/yr	814	47,215	25,988	80%	81%	80%	50%	13%	13%
7	Consolidation Conduit to Primary Treatment, 0 overflows/yr	1,012	55,998	30,822	99.998%	96%	95%	62%	15%	16%
8	Consolidation Conduit to Primary Treatment, 2 overflows/yr	1,011	51,047	27,478	99.915%	88%	85%	62%	14%	14%
9	Consolidation Conduit to Screening/Disinfection, 0 overflows/yr	1,012	30,077	15,938	99.981%	52%	49%	62%	8%	8%
10	Targeted Sewer Separation with Storage Conduit, 0 overflows/yr	1,012	58,030	32,331	100%	100%	100%	63%	12%	8%
11	Targeted Sewer Separation with Storage Conduit, 2 overflows/yr	932	53,682	29,781	92%	93%	92%	59%	11%	7%
12	Targeted Sewer Separation with Storage Conduit, 4 overflows/yr	885	51,086	28,259	87%	88%	87%	56%	10%	6%
13	Targeted Sewer Separation with Storage Conduit and Tank, 0 overflows/yr	1,012	58,030	32,331	100%	100%	100%	63%	12%	8%
14	Targeted Sewer Separation with Screening/Disinfection Facility, 0 overflows/yr	1,012	54,924	30,509	99.998%	95%	94%	63%	12%	7%
15	Targeted Sewer Separation, Alternative A	861	49,821	27,517	85%	86%	85%	54%	10%	6%
16	Targeted Sewer Separation, Alternative B	906	52,262	28,948	90%	90%	90%	55%	8%	3%
17	Targeted Sewer Separation, AltB w/all CAM002	935	53,815	29,859	92%	93%	92%	56%	5%	1%
18	Targeted Separation CAM004 only	513	30,854	16,393	51%	53%	51%	32%	4%	1%
19	Total Sewer Separation	1,012	58,030	32,331	100%	100%	100%	49%	-14%	-13%

Section Six

CHAPTER SIX
EVALUATION OF CSO CONTROL ALTERNATIVES

This chapter presents a comparison of the CSO control alternatives for Alewife Brook that were developed and described in Chapter Five. The alternatives are compared on the basis of cost per unit of pollutant load removed, cost/performance curves, water quality impacts, affordability and non-monetary factors.

COST PER POLLUTANT LOAD REMOVED

Table 6-1 presents cost data, net present value per pollutant load removed for CSO pollutant loads only, net present value per pollutant load removed for total pollutant loads, and annual performance data for the alternatives presented in Chapter Five. For CSO loads only, the alternative with the least cost per pollutant load removed for all three pollutants considered (fecal coliform bacteria, TSS and BOD) was Targeted Sewer Separation Alternative A, which included separation of CAM004 and CAM400, relieving the Rindge Avenue siphon, providing a hydraulic relief gate at outfall MWR003, and enlarging the dry weather flow connections at CAM002, CAM401B and SOM01A. The alternative with the next-lowest cost per load removed for all three parameters was Targeted Sewer Separation Alternative B, which was similar to Alternative A, but included separation of the Massachusetts Avenue combined sewer upstream of Cedar Street. Following these two alternatives, the third-lowest cost per load removed was an expansion of Alternative B to include complete separation upstream of outfall CAM002.

In terms of cost per total load reduction, Targeted Sewer Separation Alternative A had the lowest cost per load removed for fecal coliform bacteria and TSS. Targeted Sewer Separation Alternative B had the next-lowest cost per total fecal coliform bacteria load removed, followed again by the expansion of Alternative B to include complete separation upstream of CAM002.

TABLE 6-1 - SUMMARY OF COST PER UNIT LOAD REMOVED FOR CSO CONTROL ALTERNATIVES

ALTERNATIVE		COST DATA			NET PRESENT VALUE COST PER LOAD REMOVED CSO ONLY			NET PRESENT VALUE COST PER LOAD REMOVED TOTAL LOAD			Annual Performance							
											Untreated CSO*		Treated CSO					
													Primary Treatment		< Primary Treat.		Screening/Disinfection	
Number	DESCRIPTION	Capital Cost, Millions $	Annual O&M Cost, $	Net Present Value, Millions $	Fecal Coliform Bacteria, $/# X 10^{12}	Total Suspended Solids $/lbs	Biochemical Oxygen Demand $/lbs	Fecal Coliform Bacteria, $/# X 10^{12}	Total Suspended Solids $/lbs	Biochemical Oxygen Demand $/lbs	Activation Frequency	Total Vol. (MG)	Activation Frequency	Total Vol. (MG)	Activation Frequency	Total Vol. (MG)	Activation Frequency	Total Vol. (MG)
1	Consolidated Storage Conduit, 0 untreated overflows/yr	$145.1	$225,000	$139.5	$137,838	$2,404	$4,315	$137,838	$2,404	$4,315	0	0	N/A		N/A		N/A	
2	**Consolidated Storage Conduit, 2 untreated overflows/yr (****)**	$115.0	$225,000	$111.4	$126,255	$2,186	$3,952	$126,255	**$2,186**	**$3,952**	2	6.4	N/A		N/A		N/A	
3	Consolidated Storage Conduit, 4 untreated overflows/yr	$113.4	$225,000	$109.9	$131,923	$2,276	$4,130	$131,923	$2,276	$4,130	4	8.8	N/A		N/A		N/A	
4	Consolidation Conduit to Storage Tank, 0 untreated overflows/yr	$141.6	$757,000	$145.1	$143,372	$2,500	$4,488	$143,372	$2,500	$4,488	0	0	N/A		N/A		N/A	
5	**Consolidation Conduit to Storage Tank, 2 untreated overflows/yr (****)**	$112.6	$522,000	$114.1	$131,008	$2,266	$4,101	$131,008	$2,266	**$4,101**	2	6.9	N/A		N/A		N/A	
6	**Consolidation Conduit to Storage Tank, 4 untreated overflows/yr (****)**	$104.6	$522,000	$106.5	$130,914	$2,256	$4,098	$130,914	**$2,256**	**$4,098**	4	9.8	N/A		N/A		N/A	
7	Consolidation Conduit to Primary Treatment, 0 partially-treated overflows/yr	$157.2	$499,000	$155.3	$153,453	$2,773	$5,039	$153,453	$2,773	$5,039	0	0	2	2.9	0	0	0	0
8	Consolidation Conduit to Primary Treatment, 2 partially-treatedoverflows/yr	$128.1	$499,000	$128.2	$126,781	$2,511	$4,666	$126,781	$2,511	$4,666	0	0	3	4.1	2**	4.4	0	0
9	Consol. Cond. to Screening/Disinf., 0 partially-treated overflows/yr	$108.3	$342,000	$107.0	$105,745	$3,557	$6,714	$105,745	$3,557	$6,714	0	0	N/A		N/A		8	25.2
10	Partial Sewer Separation with Storage Conduit, 0 untreated overflows/yr	$145.3	$223,000	$139.6	$137,937	$2,406	$4,318	$135,679	$3,063	$8,688	0	0	N/A		N/A		N/A	
11	Partial Sewer Separation with Storage Conduit, 2 untreated overflows/yr	$111.6	$223,000	$108.2	$116,066	$2,016	$3,633	$114,006	$2,624	$8,004	2	3.9	N/A		N/A		N/A	
12	**Partial Sewer Separation with Storage Conduit, 4 untr. overflows/yr (****)**	$98.0	$223,000	$95.3	$107,735	$1,865	$3,372	$105,721	$2,466	$7,945	4	6.3	N/A		N/A		N/A	
13	Partial Sewer Separation with Storage Conduit and Tank, 0 untreated overflows/yr	$140.4	$480,000	$139.3	$137,641	$2,400	$4,309	$135,387	$3,056	$8,669	0	0	N/A		N/A		N/A	
14	Partial Sewer Separation with Screening/Disinfection Facility, 0 partially-treated overflows/yr	$130.5	$336,000	$127.6	$126,083	$2,323	$4,182	$124,019	$3,004	$8,957	0	0	N/A		N/A		2	2.8
15	**Partial Sewer Separation, Alternative A (****)**	$73.7	-$5,400	$68.8	**$79,873**	**$1,381**	**$2,500**	**$78,341**	**$1,841**	$6,113	5 to 7	7.4	N/A		N/A		N/A	
16	**Partial Sewer Separation, Alternative B (****)**	$82.5	-$7,700	$77.1	**$85,084**	**$1,475**	**$2,663**	**$85,699**	$2,760	$11,852	5 to 8	5.2	N/A		N/A		N/A	
17	**Targeted Sewer Separation, AltB w/all CAM002 (****)**	$95.8	-$9,400	$89.4	**$95,648**	**$1,661**	**$2,994**	**$98,337**	$4,518	$37,652	4 to 6	3.8	N/A		N/A		N/A	
18	Targeted Separation CAM004 only	$71.8	-$4,100	$67.1	$130,760	$2,175	$4,093	$130,932	$4,191	$34,966	24	24.5	N/A		N/A		N/A	
19	Total Sewer Separation	$186.1	-$19,100	$153.1	$151,276	$2,638	$4,735	$192,099	N/A***	N/A***	0	0	N/A		N/A		N/A	

Notes: * "Untreated CSO" defined as discharge receiving floatables control, only.

** During two of the four annual discharges per year from the primary treatment facility, the design overflow rate for primary treatment will be exceeded.

*** N/A - Not Applicable; Total load increases as a result of alternative.

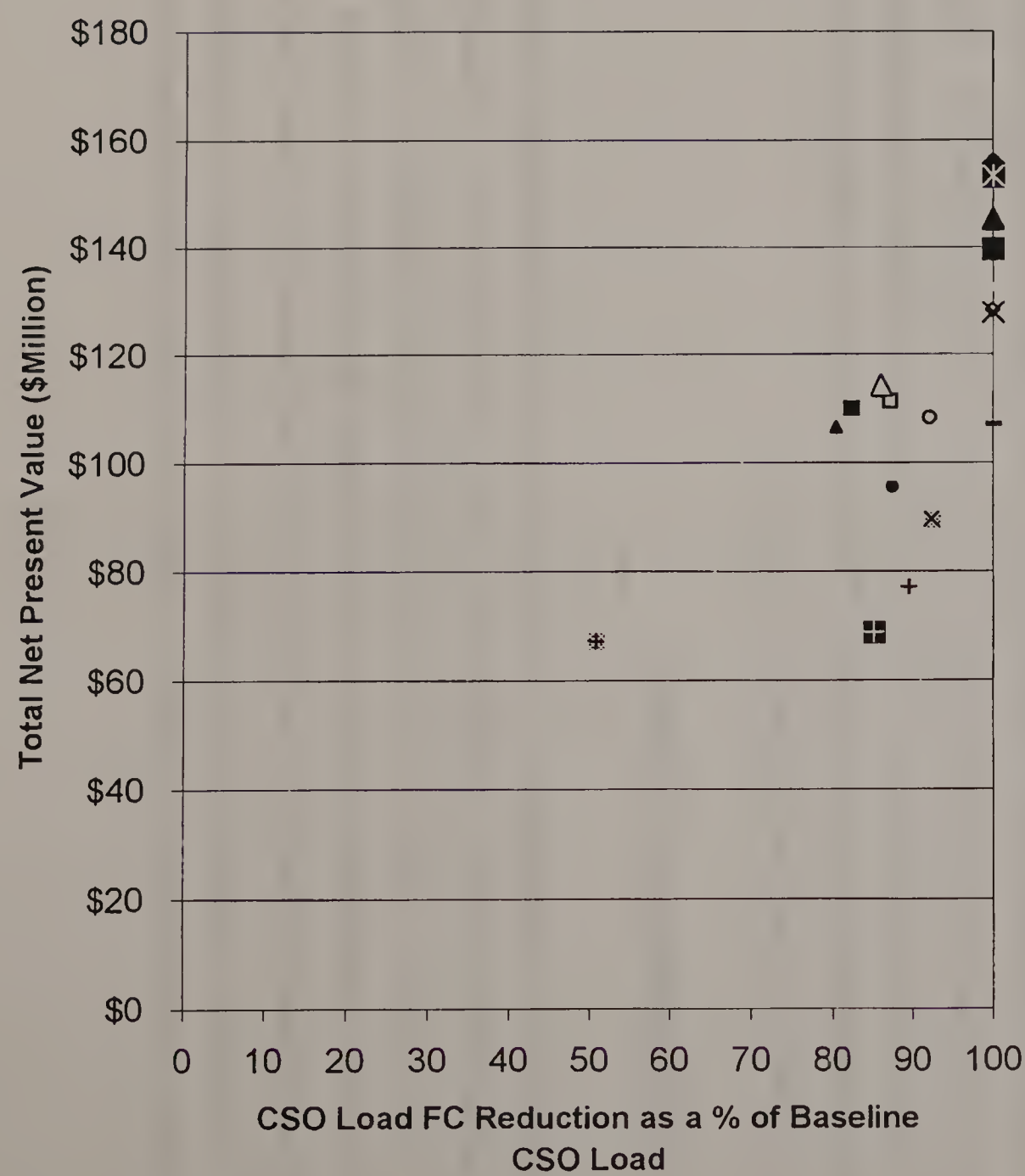
(****) The three lowest unit costs per pollutant load removed for each parameter are indicated in bold.

The consolidation/storage conduit sized for two over-flows per year had the next-lowest cost per total load removed for TSS, followed by consolidation to a storage tank sized for four overflows per year. The consolidation/storage conduit sized for two overflows per year had the lowest unit cost for total BOD load removed, followed by the consolidation to a storage tank sized for four and two overflows per year, respectively.

In summary, Targeted Sewer Separation Alternative A had the lowest cost per CSO pollutant load removed for fecal coliform bacteria, TSS and BOD, followed by Targeted Sewer Separation Alternative B. Targeted Sewer Separation Alternative A also had the lowest cost per total pollutant load removed for fecal coliform bacteria and TSS. The cost-effectiveness of the targeted sewer separation alternatives in terms of total pollutant load removal was enhanced based on the expected performance of the CAM004 stormwater detention basin in reducing bacteria and TSS loads discharged to the Little River following separation of the CAM004 area. The cost-effectiveness of the targeted sewer separation alternatives with regard to control of bacteria, TSS and BOD may continue to improve, as the quality of stormwater runoff improves through implementation of BMPs and control of sanitary flow cross-connections. Thus, on a cost-per-unit load removed basis, Targeted Sewer Separation Alternative A was determined to be the most cost-effective, especially for the pollutants of most concern (bacteria and TSS), followed by Targeted Sewer Separation Alternative B.

COST/PERFORMANCE CURVES

Figures 6-1 to 6-3 present plots of net present value versus CSO load reduction as a percent of baseline CSO load for fecal coliform bacteria, TSS and BOD, respectively. For each figure, the "knee-of-the-curve" appears to be at Targeted Sewer Separation Alternative A. For most alternatives, performance ranged between approximately 80 and 100 percent removal. Targeted Sewer Separation Alternative A would achieve 85 percent annual fecal coliform load removal. The net present value of the lowest-cost alternative that achieves approximately 100 percent fecal coliform bacteria removal (consolidation conduit with screening and disinfection; 99.98 percent



- ■ Consolidated Storage Conduit, 0 overflows/yr
- □ Consolidated Storage Conduit, 2 overflows/yr
- ■ Consolidated Storage Conduit, 4 overflows/yr
- ▲ Consolidation Conduit to Storage Tank, 0 overflows/yr
- △ Consolidation Conduit to Storage Tank, 2 overflows/yr
- ▲ Consolidation Conduit to Storage Tank, 4 overflows/yr
- ◆ Consolidation Conduit to Primary Treatment, 0 overflows/yr
- ◇ Consolidation Conduit to Primary Treatment, 2 overflows/yr
- – Consolidation Conduit to Screening/Disinfection, 0 overflows/yr
- ● Sewer Separation with Storage Conduit, 0 overflows/yr
- ○ Sewer Separation with Storage Conduit, 2 overflows/yr
- • Sewer Separation with Storage Conduit, 4 overflows/yr
- ✱ Sewer Separation with Storage Conduit and Tank, 0 overflows/yr
- × Sewer Separation with Screening/Disinfection Facility, 0 overflows/yr
- ⊞ Sewer Separation, Alternative A
- + Sewer Separation, Alternative B
- ⊠ Total Sewer Separation
- ✱ Targeted Sewer Separation, AltB w/all CAM002
- ✱ Targeted Separation CAM004 only

FIGURE 6-1. CSO FC REDUCTION AS A PERCENT OF CSO BASELINE LOAD

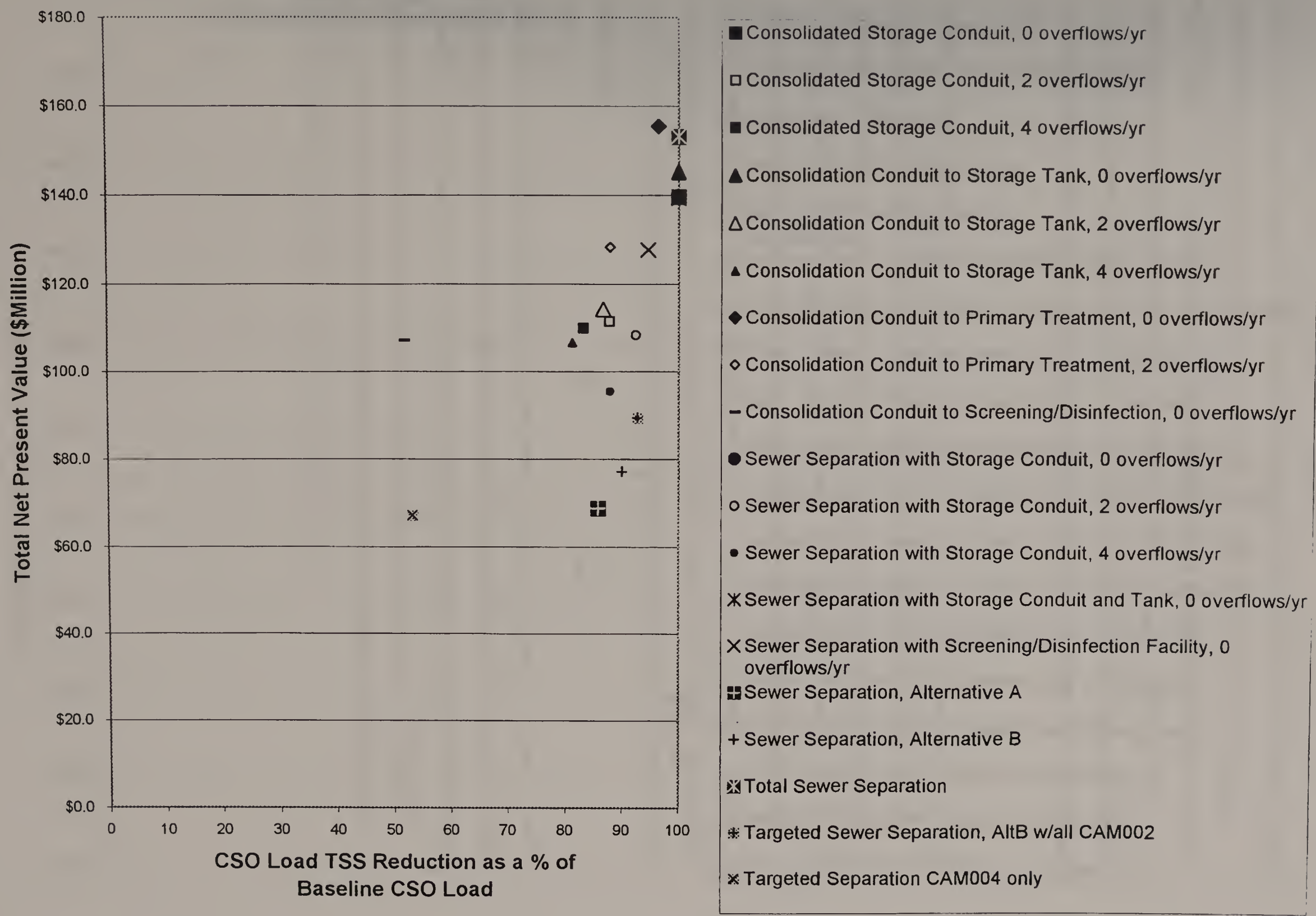


FIGURE 6-2. CSO TSS LOAD REDUCTION AS A PERCENT OF BASELINE CSO TSS LOAD

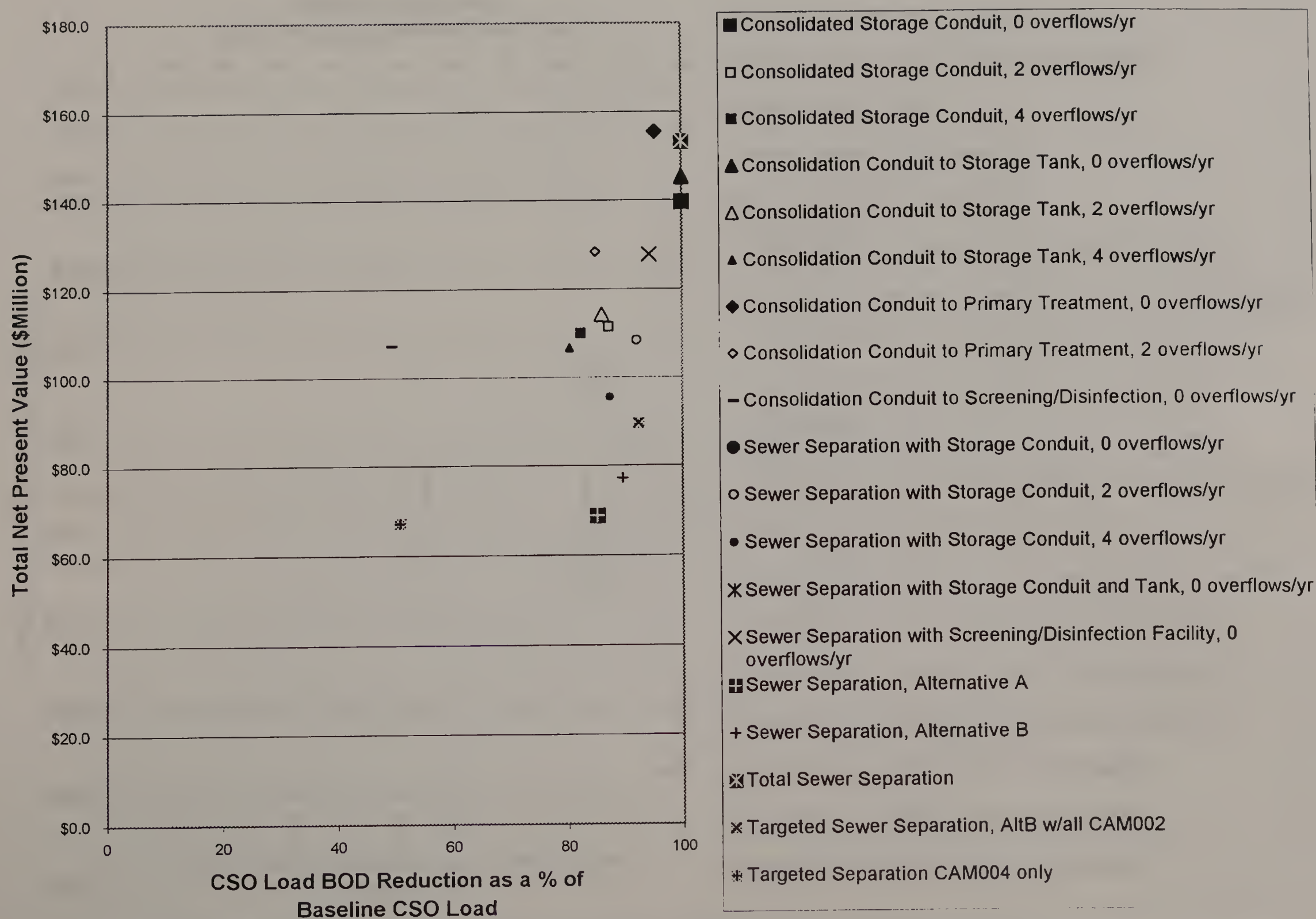
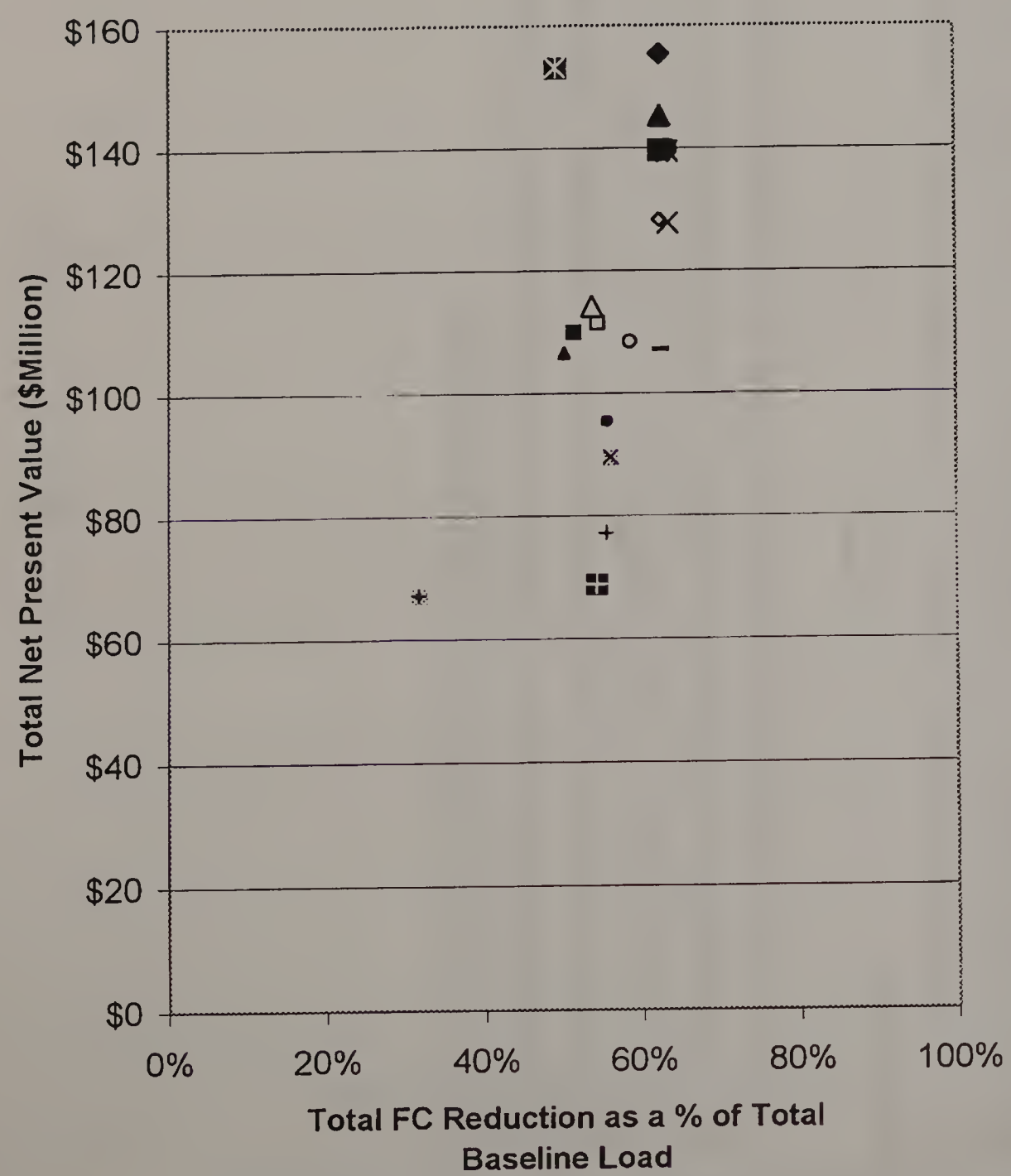


FIGURE 6-3. CSO BOD LOAD REDUCTION AS A PERCENT OF BASELINE CSO BOD LOAD

fecal coliform bacteria removal) would be almost 60 percent greater than the net present value of Targeted Sewer Separation Alternative A. For BOD and TSS, moving from the 85 percent removal achieved by Targeted Sewer Separation Alternative A to 100 percent removal would require nearly doubling the net present value. For fecal coliform bacteria, TSS and BOD, even a more modest improvement in performance (90 percent vs. 85 percent removal) over Targeted Sewer Separation Alternative A would require at least an $8 million increase in the net present value.

Figures 6-4 to 6-6 present plots of net present value versus total load reduction as a percent of baseline total load for fecal coliform bacteria, TSS and BOD, respectively. While the fecal coliform plot appears to show a knee-of-the-curve at Targeted Sewer Separation Alternative A, the TSS and BOD plots do not exhibit a distinct "knee". For most alternatives, fecal coliform bacteria removals ranged between approximately 50 and 65 percent, while TSS and BOD removals ranged from less than zero (net increase in load) to less than 20 percent. Targeted Sewer Separation Alternative A would achieve 54 percent annual fecal coliform load removal. Improving to approximately 65 percent removal would require a 55-percent increase in the net present value.

Figures 6-1 to 6-6 indicate that while Targeted Sewer Separation Alternative A may be on the low end of performance in terms of percent removal, the spread between the lowest and highest performance is not that wide. Targeted Sewer Separation Alternative A appears to be located at the knee of the curve in each of the figures where a knee can be discerned. In effect, these figures indicate that compared with Targeted Sewer Separation Alternative A, higher-cost alternatives yield only marginal improvements in performance.



- ■ Consolidated Storage Conduit, 0 overflows/yr
- □ Consolidated Storage Conduit, 2 overflows/yr
- ■ Consolidated Storage Conduit, 4 overflows/yr
- ▲ Consolidation Conduit to Storage Tank, 0 overflows/yr
- △ Consolidation Conduit to Storage Tank, 2 overflows/yr
- ▲ Consolidation Conduit to Storage Tank, 4 overflows/yr
- ◆ Consolidation Conduit to Primary Treatment, 0 overflows/yr
- ◇ Consolidation Conduit to Primary Treatment, 2 overflows/yr
- – Consolidation Conduit to Screening/Disinfection, 0 overflows/yr
- ● Sewer Separation with Storage Conduit, 0 overflows/yr
- ○ Sewer Separation with Storage Conduit, 2 overflows/yr
- • Sewer Separation with Storage Conduit, 4 overflows/yr
- ✱ Sewer Separation with Storage Conduit and Tank, 0 overflows/yr
- ✕ Sewer Separation with Screening/Disinfection Facility, 0 overflows/yr
- ✚ Sewer Separation, Alternative A
- + Sewer Separation, Alternative B
- ⊠ Total Sewer Separation
- ✱ Targeted Sewer Separation, AltB w/all CAM002
- ✱ Targeted Separation CAM004 only

FIGURE 6-4. TOTAL FC REDUCTION AS A PERCENT OF TOTAL BASELINE LOAD

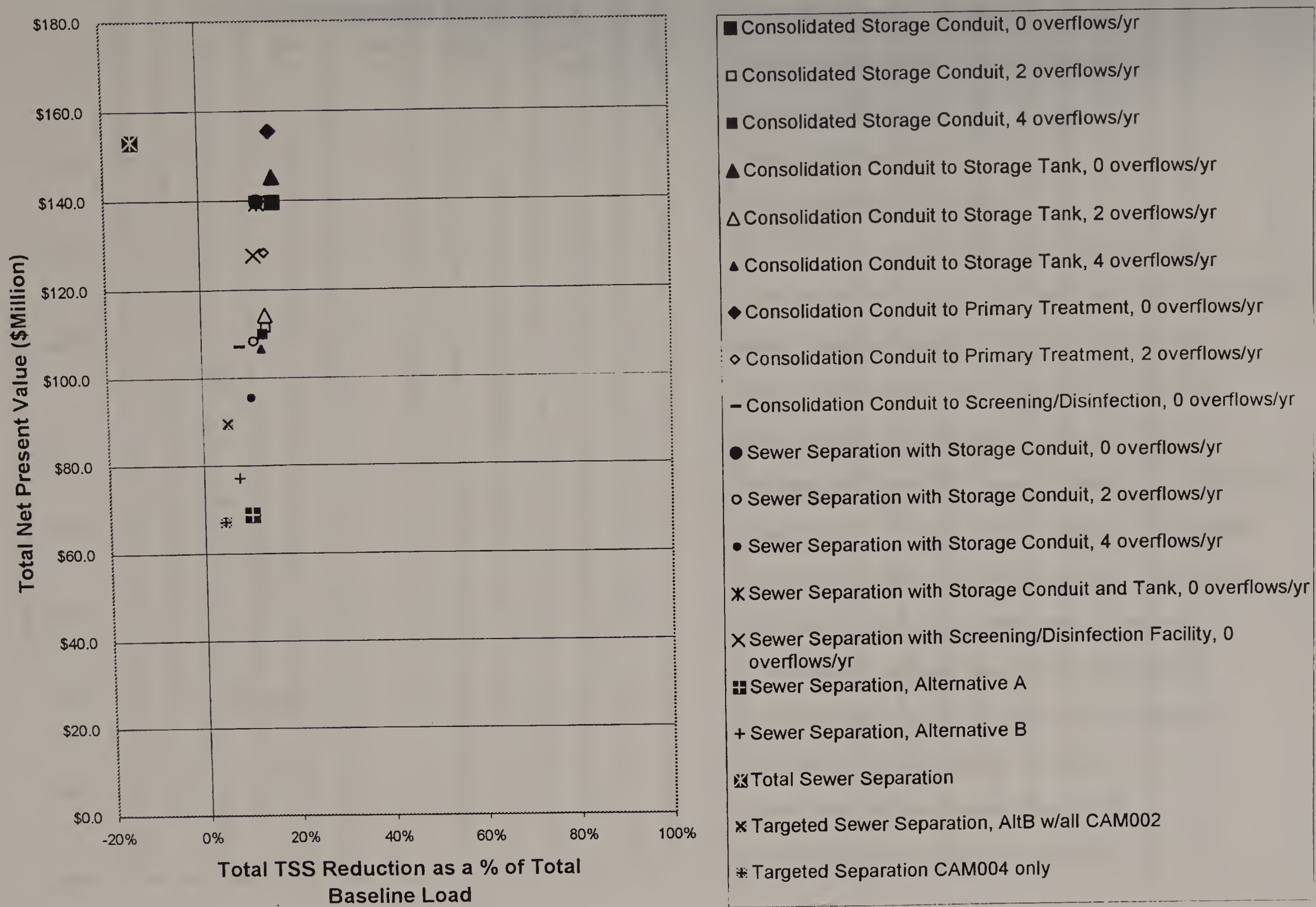


FIGURE 6-5. TOTAL TSS LOAD REDUCTION AS A % OF TOTAL BASELINE TSS LOAD

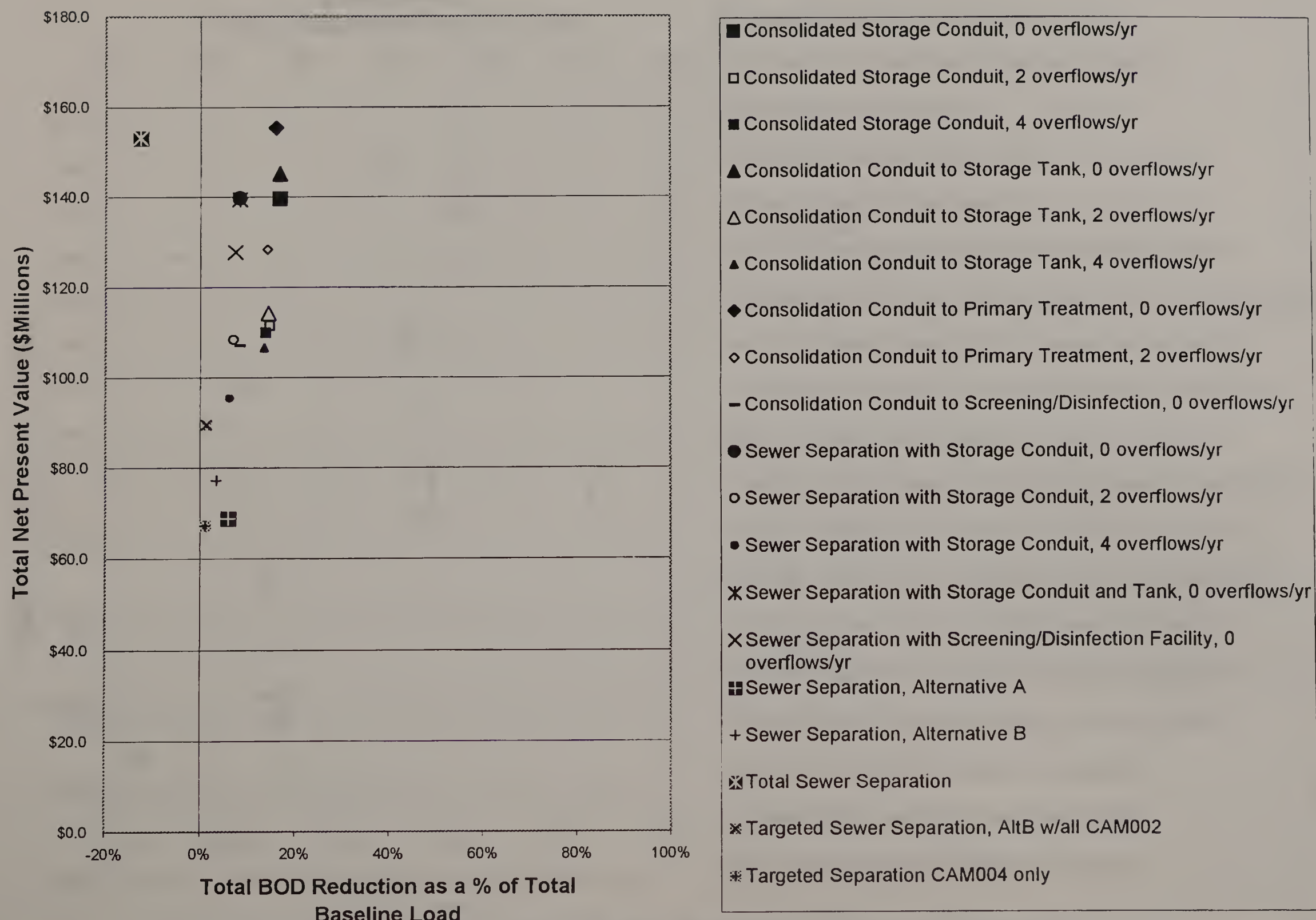


FIGURE 6-6. TOTAL BOD LOAD REDUCTION AS A % OF TOTAL BASELINE BOD LOAD

WATER QUALITY IMPACTS

Activities associated with updating the receiving water model for Alewife Brook and the Upper Mystic River, and use of the model to define baseline water quality conditions were described in Chapter Four. This model was then used to define the performance of the most cost-effective alternative (Targeted Sewer Separation Alternative A), and to help determine whether a more costly alternative would provide an improvement in benefit in terms of attainment of water quality standards commensurate with the additional cost. The following section provides a discussion of the receiving water modeling results for Targeted Sewer Separation Alternative A, followed by a presentation of calculations demonstrating compliance with the Class B_{CSO} requirement of attaining at least 95 percent compliance with Class B criteria based on CSO loads, only.

Receiving Water Modeling Results for Targeted Sewer Separation Alternative A

Figures 6-7 through 6-13 present the fecal coliform profiles in Alewife Brook and the Upper Mystic River for the 3-month storm, at the peak of the storm, and 6, 24, 48, 72, 144, and 180 hours after the peak. Presented on the plots are existing conditions (all sources), existing conditions, non-CSO sources only, and recommended plan (all sources). These plots are the same as Figures 4-12 to 4-18 that were presented in Chapter Four in the context of baseline conditions. The discussion herein focuses on the performance of Targeted Sewer Separation Alternative A (identified as the "recommended plan" in Figures 6-7 to 6-13).

Under Targeted Sewer Separation Alternative A, no CSO discharges are predicted to Alewife Brook in the 3-month, 24-hour storm. In Figure 6-7, the slightly elevated fecal coliform densities in Alewife Brook at the peak of the storm for the recommended plan compared with 2002 conditions, non-CSO sources only, is due to the additional stormwater discharge associated with the targeted sewer separation projects. Elevated fecal coliform densities in the vicinity of SOM007A are due to the SW loads from the Malden River. By six hours after the peak of the

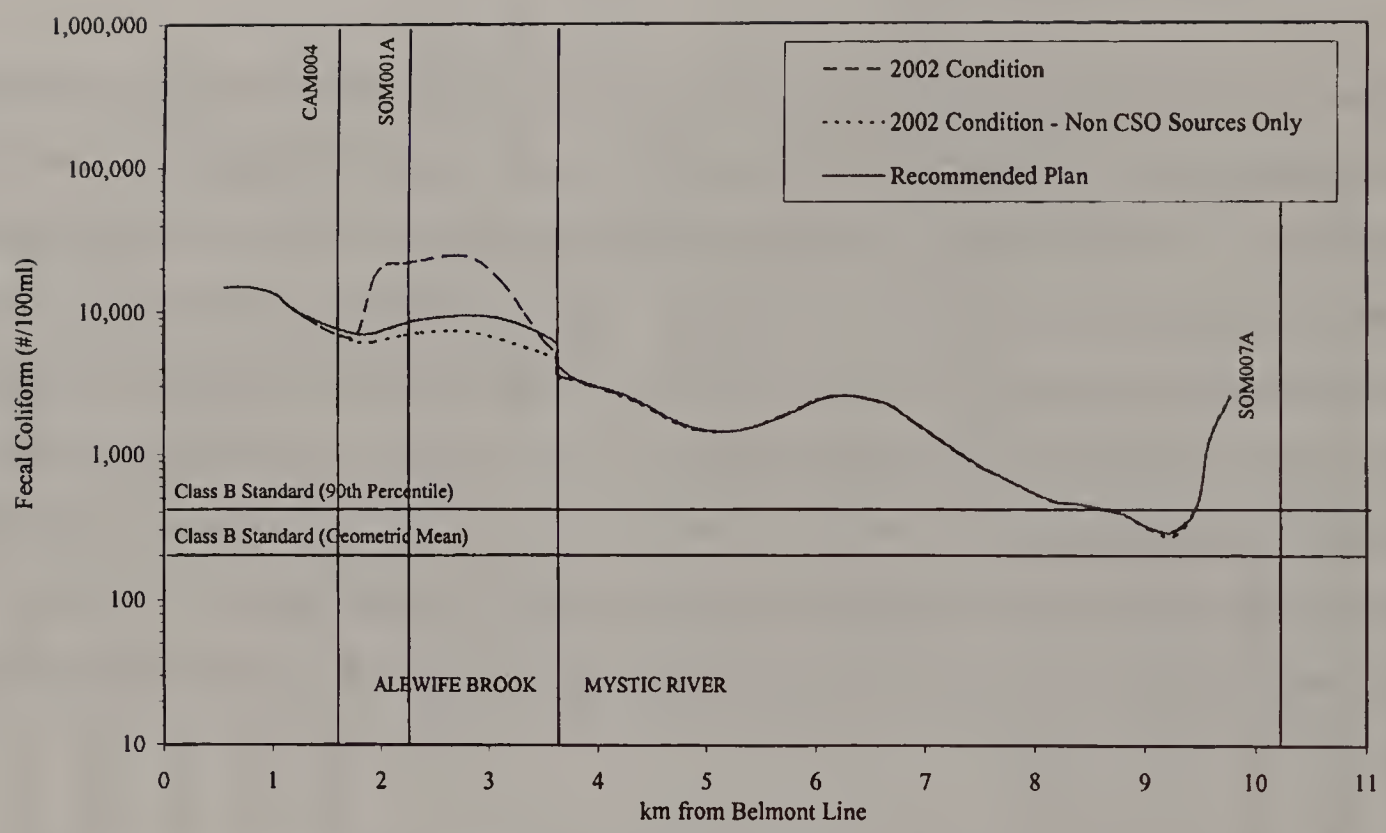


FIGURE 6-7. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
Peak of the 3-Month Storm

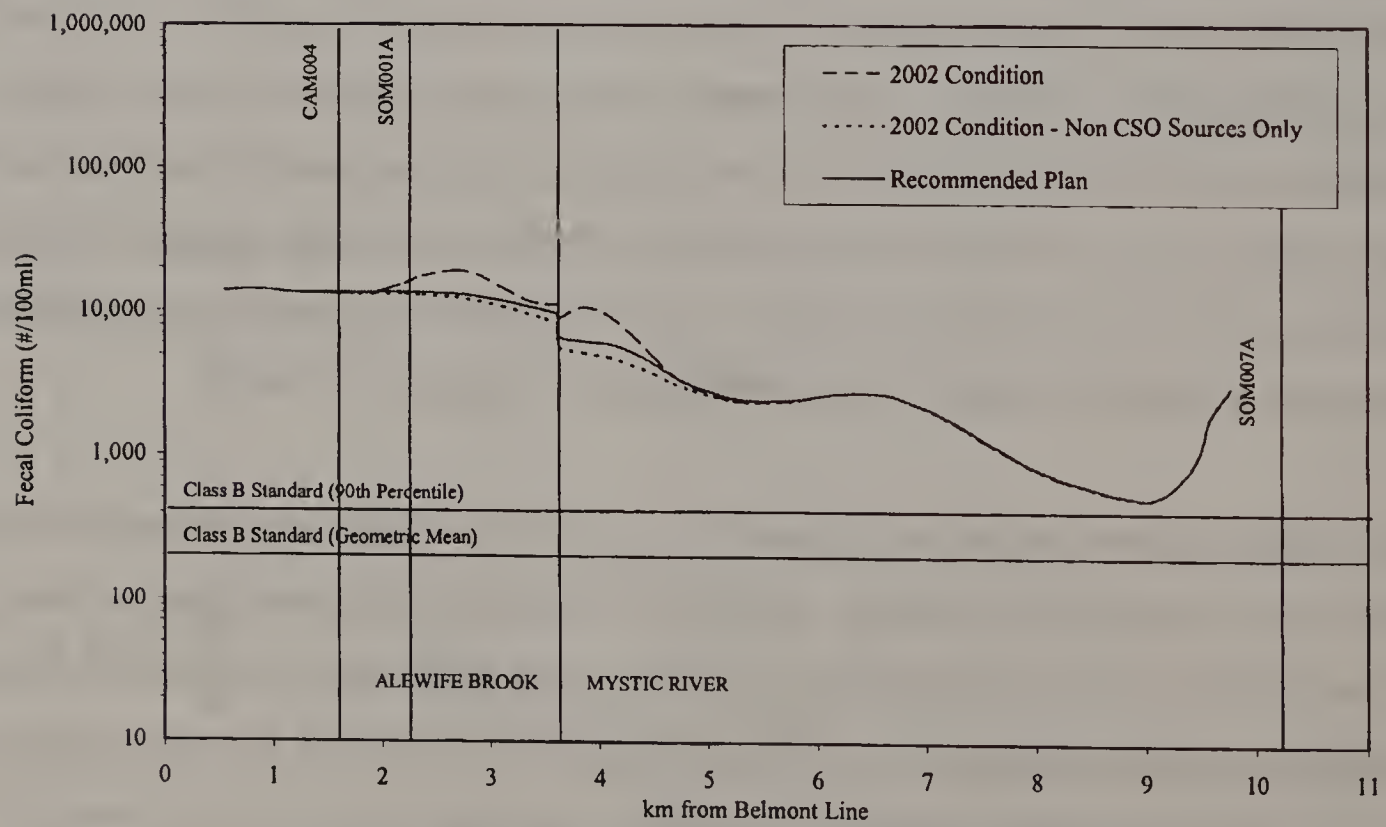


FIGURE 6-8. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
6 Hours After the Peak of the 3-Month Storm

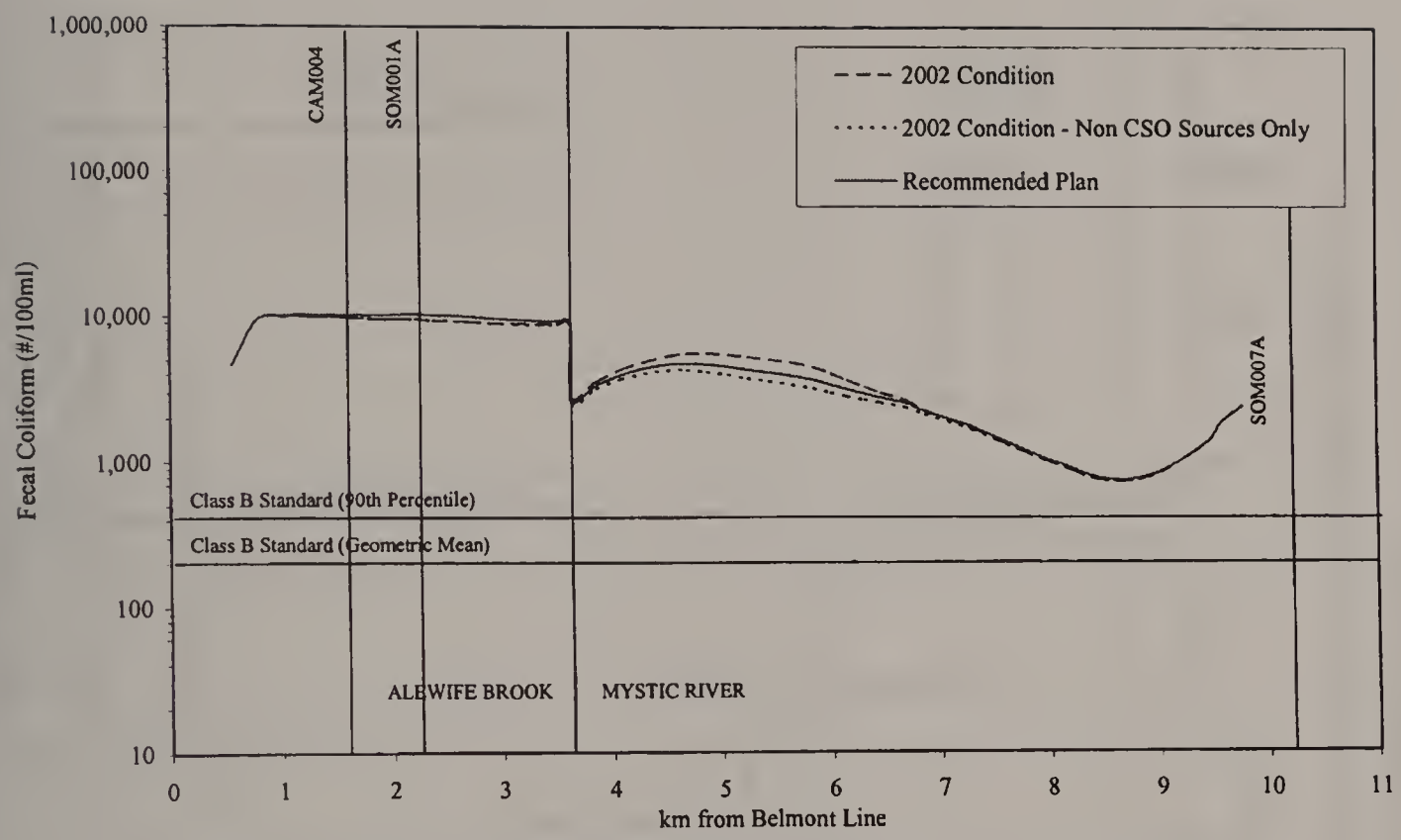


FIGURE 6-9. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
24 Hours After the Peak of the 3-Month Storm

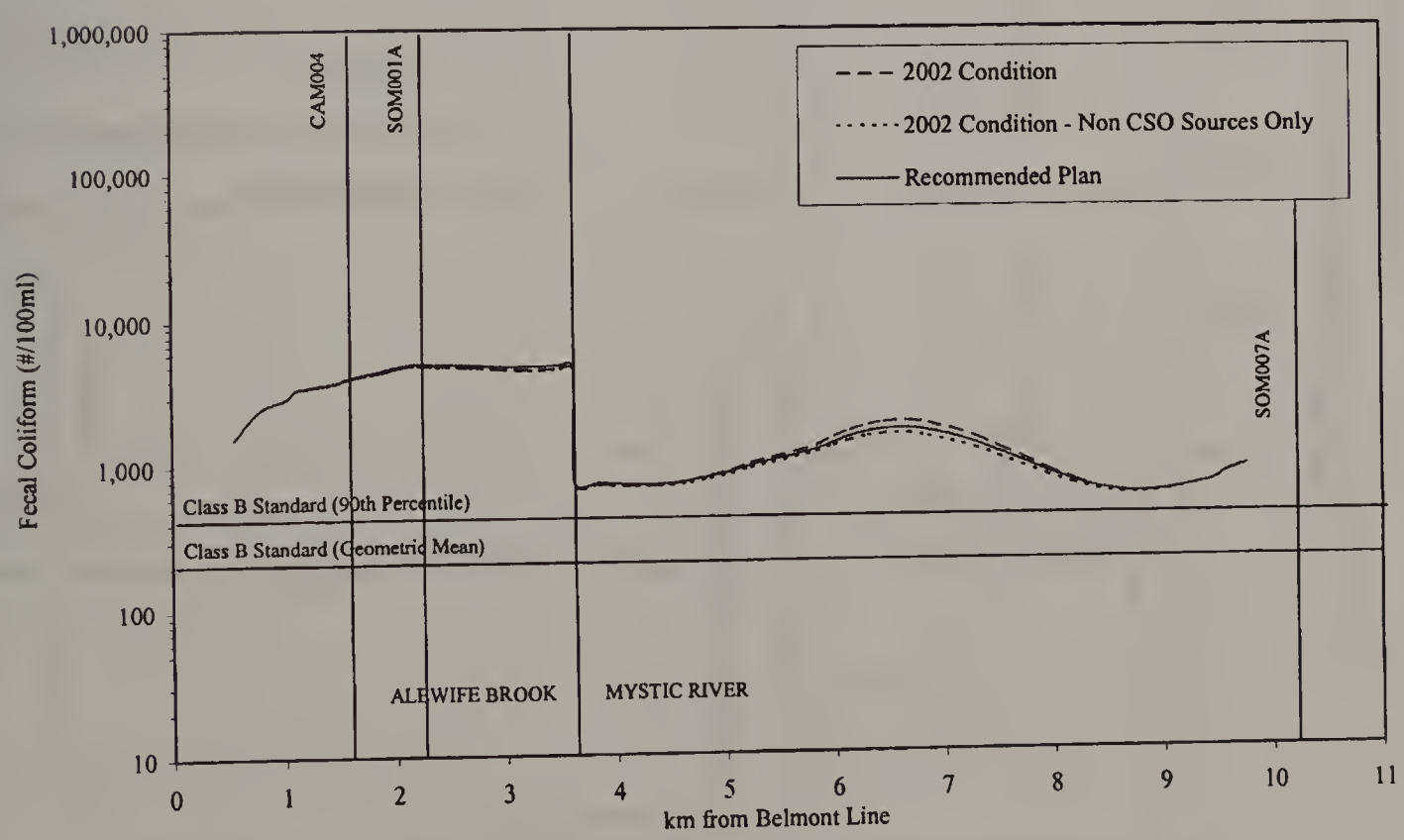


FIGURE 6-10. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
48 Hours After the Peak of the 3-Month Storm

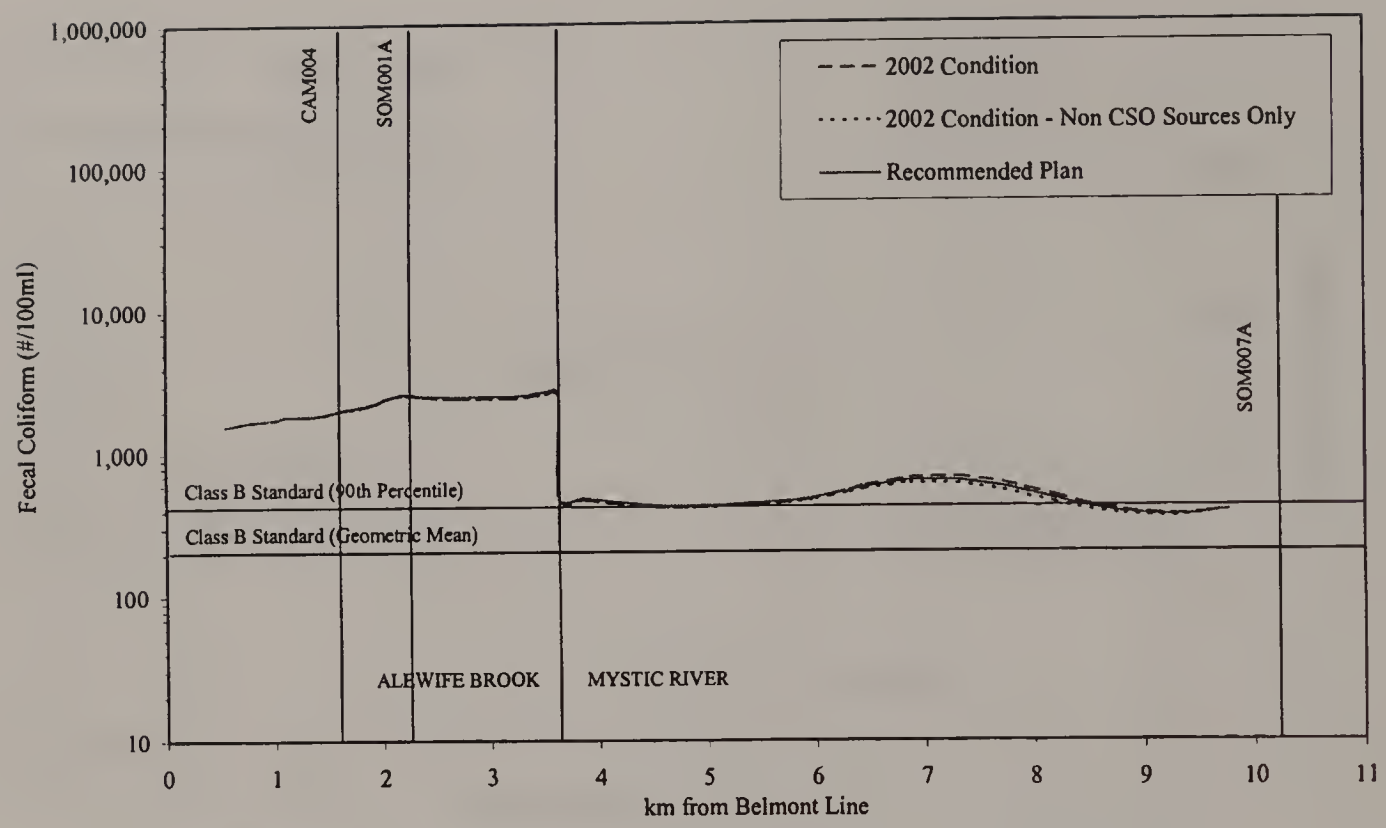


FIGURE 6-11. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
72 Hours After the Peak of the 3-Month Storm

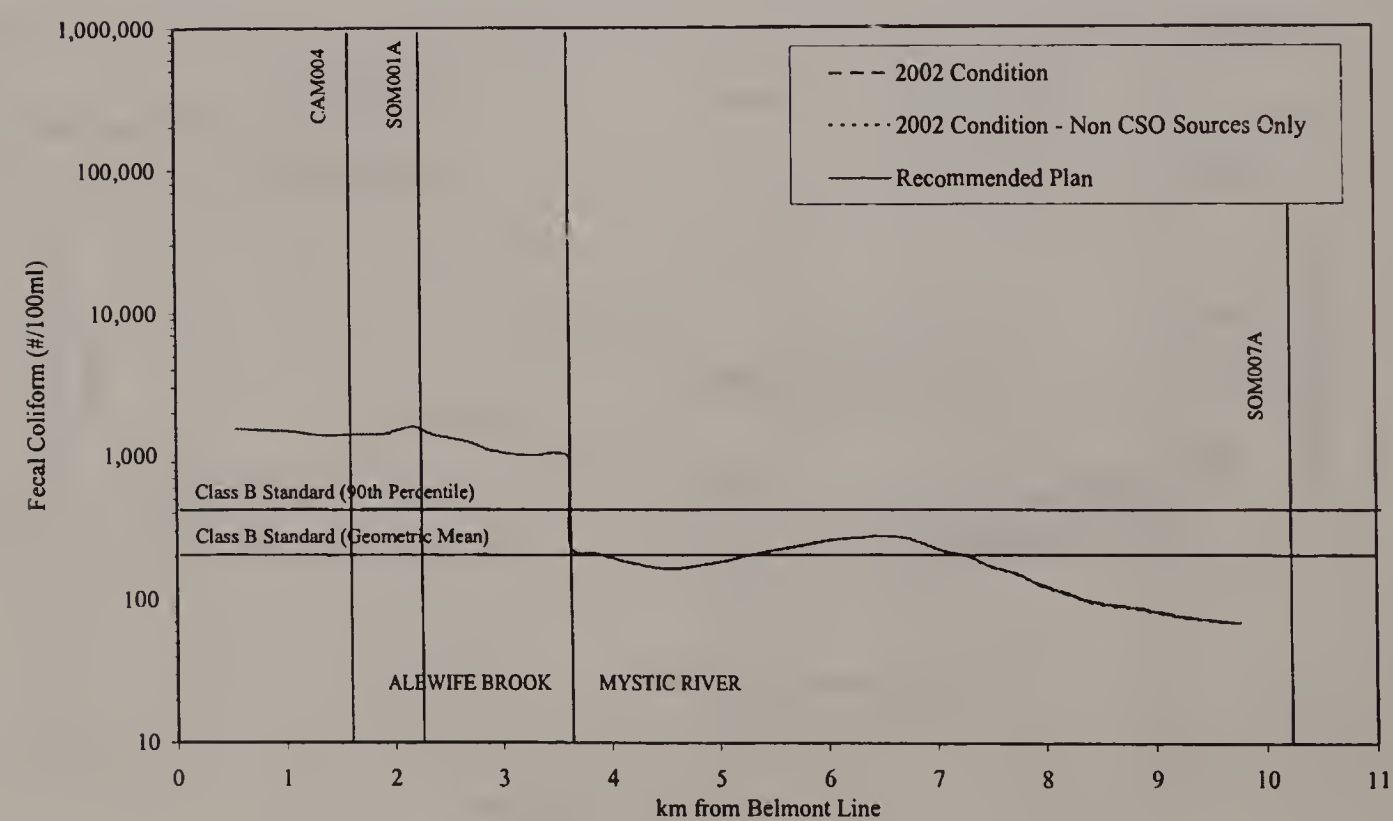


FIGURE 6-12. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
144 Hours After the Peak of the 3-Month Storm

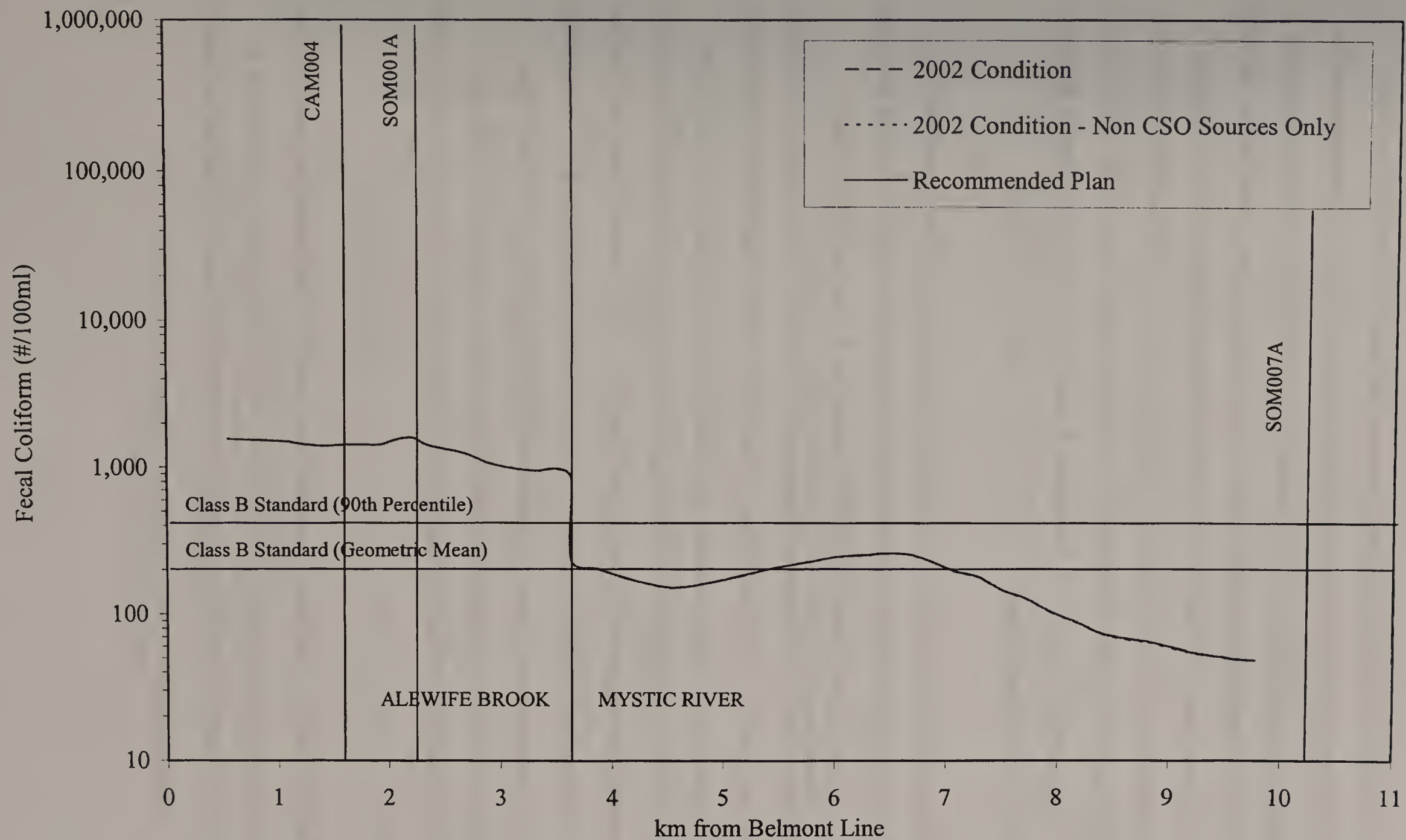


FIGURE 6-13. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
180 Hours After the Peak of the 3-Month Storm

storm (Figure 6-8), there is very little difference between the recommended plan and 2002 conditions, non-CSO sources only. As noted in Chapter Four, the Class B bacteria standard is currently violated in Alewife Brook during dry weather. The impact of non-CSO wet weather sources on bacteria concentrations in Alewife Brook in the 3-month storm extends from the peak of the storm to approximately 84 hours after the peak. The impact of non-CSO wet weather sources on attainment of the Class B standard in the Mystic River extends from the peak of the storm to approximately 120 hours after the peak. Providing a higher level of CSO control than proposed for Targeted Sewer Separation Alternative A would not change the extent or duration of these impacts in the 3-month storm.

Figures 6-14 through 6-20 present the fecal coliform profiles in Alewife Brook and the Upper Mystic River for the 1-year storm, at the peak of the storm, and 6, 24, 48, 72, 144, and 180 hours after the peak. Under Targeted Sewer Separation Alternative A, the total CSO volume discharged to Alewife Brook in the 1-year, 24-hour storm is predicted to be reduced by 4.6 MG (64 percent) as compared with 2002 conditions. The benefit of that reduction can be seen in the reduction in the peak fecal coliform densities in Alewife Brook at the peak of the storm from approximately 106,000 to 80,000 CFU/100ml (Figure 6-14). By six hours after the peak of the storm (Figure 6-15), the impact of CSO on Alewife Brook is not discernable from the impact of the non-CSO wet weather sources. The "hump" related to both CSO and non-CSO wet weather sources gradually attenuates as it moves downstream on the Mystic River. The 64 percent reduction in CSO volume in the 1-year storm achieved through Targeted Sewer Separation Alternative A is predicted to reduce the magnitude, but not the duration of impact of CSO in the Mystic River.

The remaining CSO in the 1-year storm, however, does not affect the duration of impact of the non-CSO wet weather sources on both Alewife Brook and the Mystic River. As with the 3-month storm, the impact of non-CSO wet weather sources on bacteria concentrations in Alewife

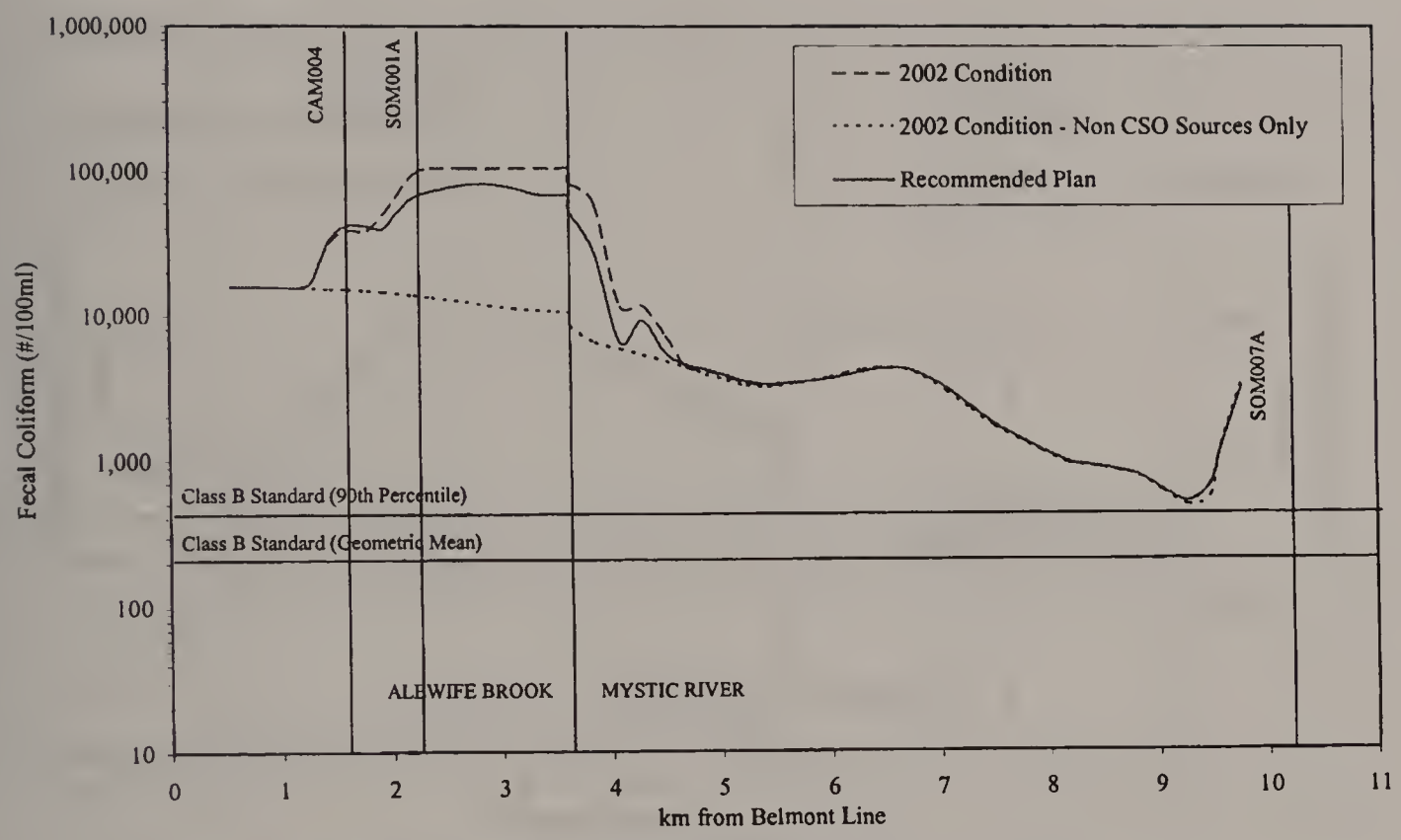


FIGURE 6-14. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
Peak of the 1-Year Storm

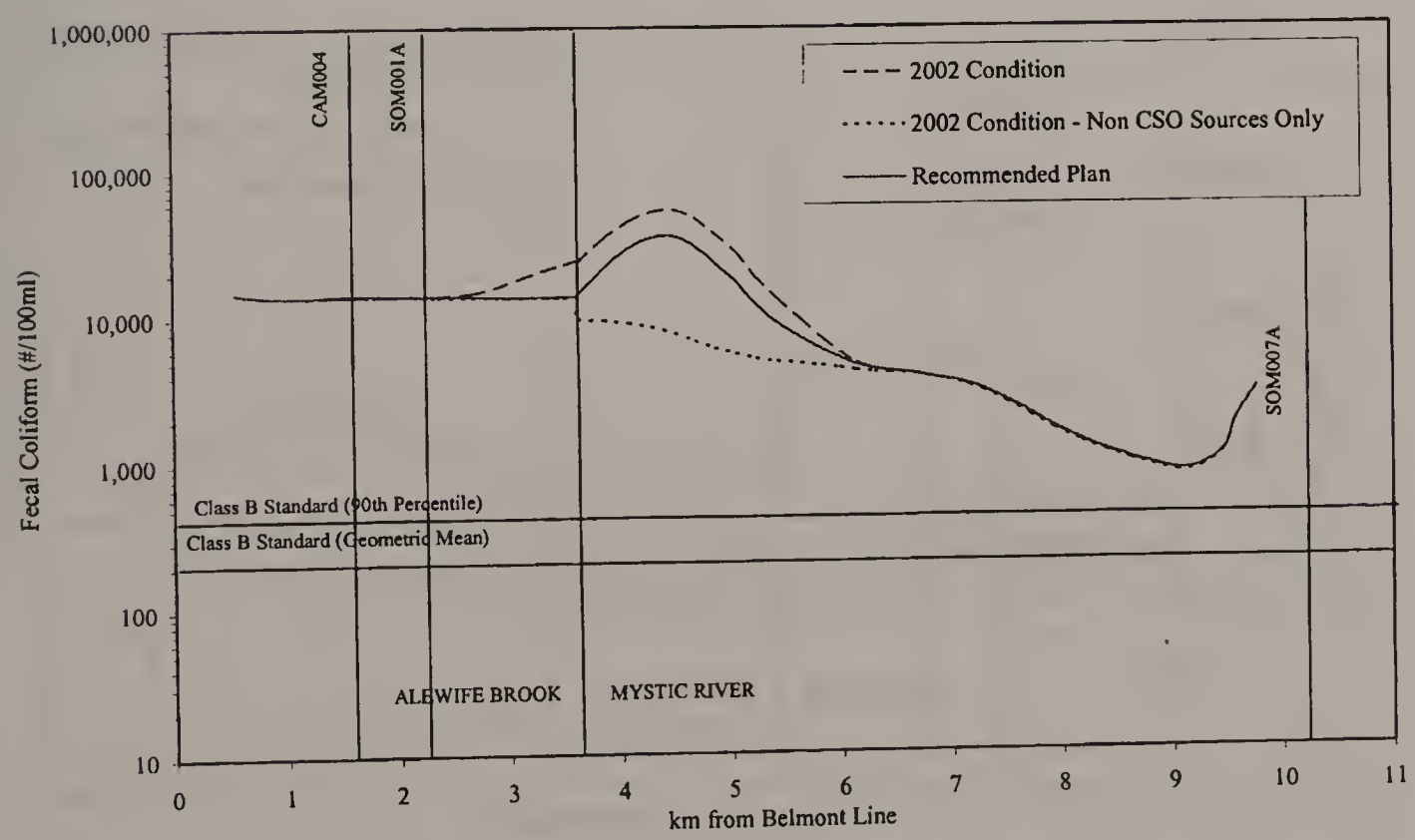


FIGURE 6-15. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
6 Hours After the Peak of the 1-Year Storm

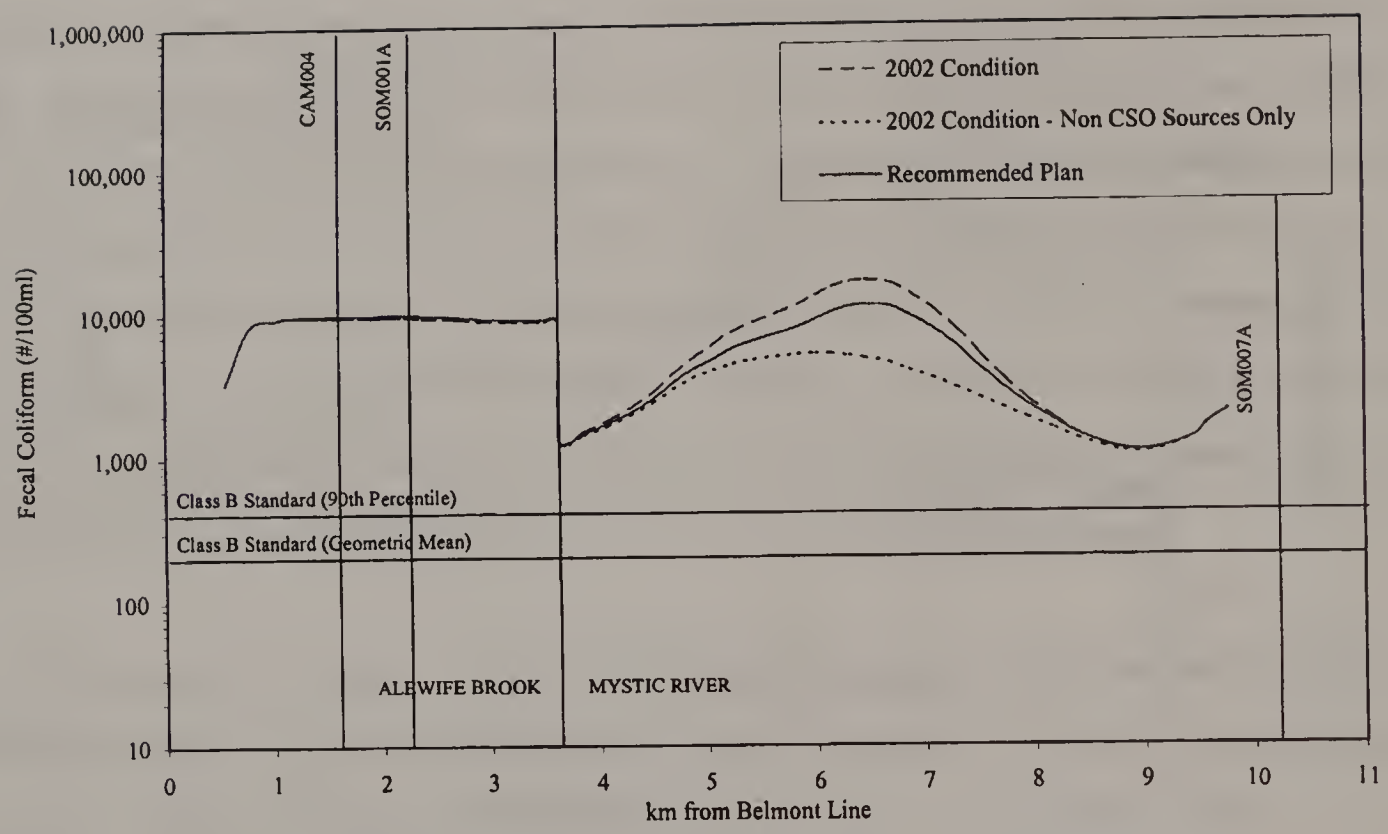


FIGURE 6-16. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
24 Hours After the Peak of the 1-Year Storm

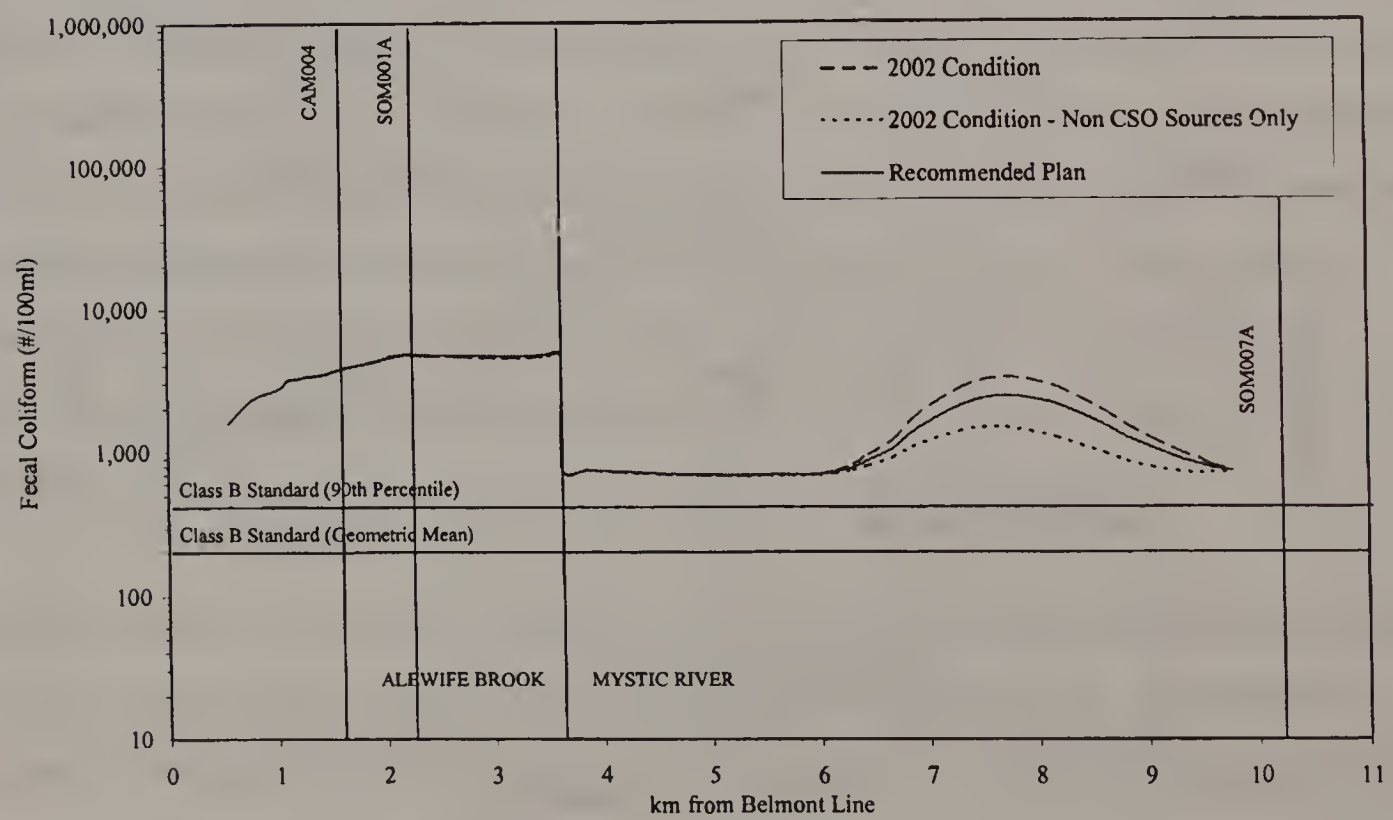


FIGURE 6-17. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
48 Hours After the Peak of the 1-Year Storm

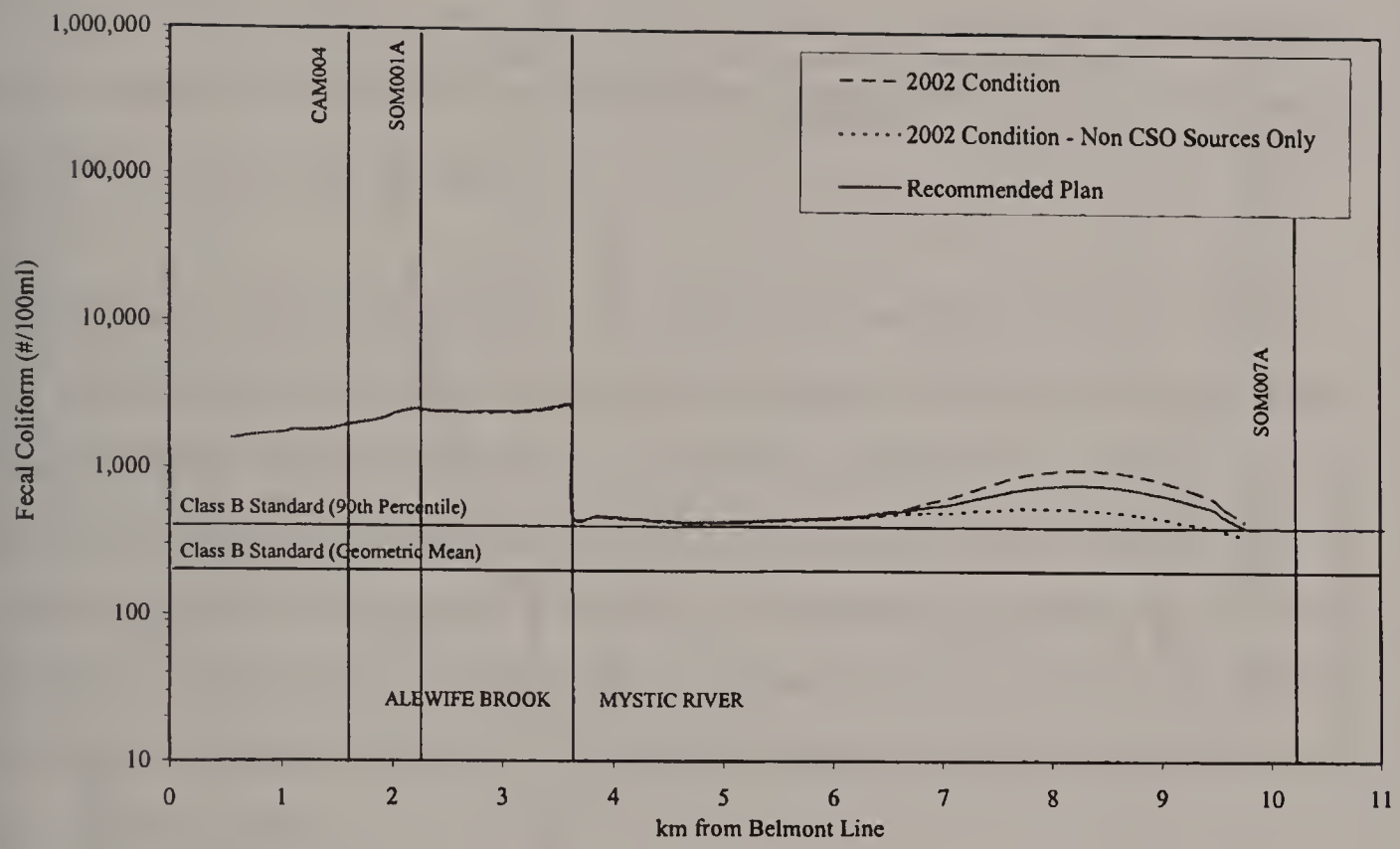


FIGURE 6-18. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
72 Hours After the Peak of the 1-Year Storm

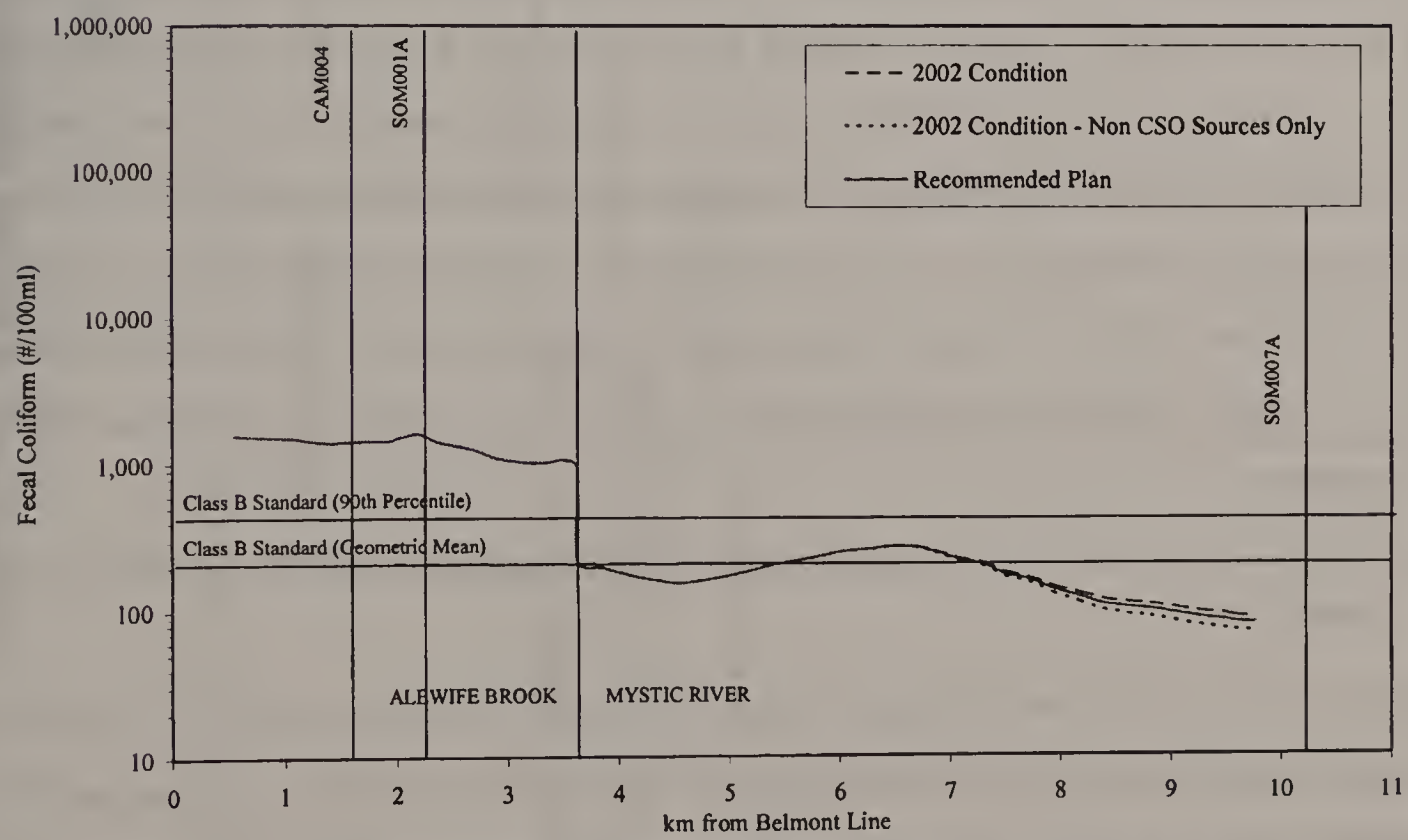


FIGURE 6-19. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
144 Hours After the Peak of the 1-Year Storm

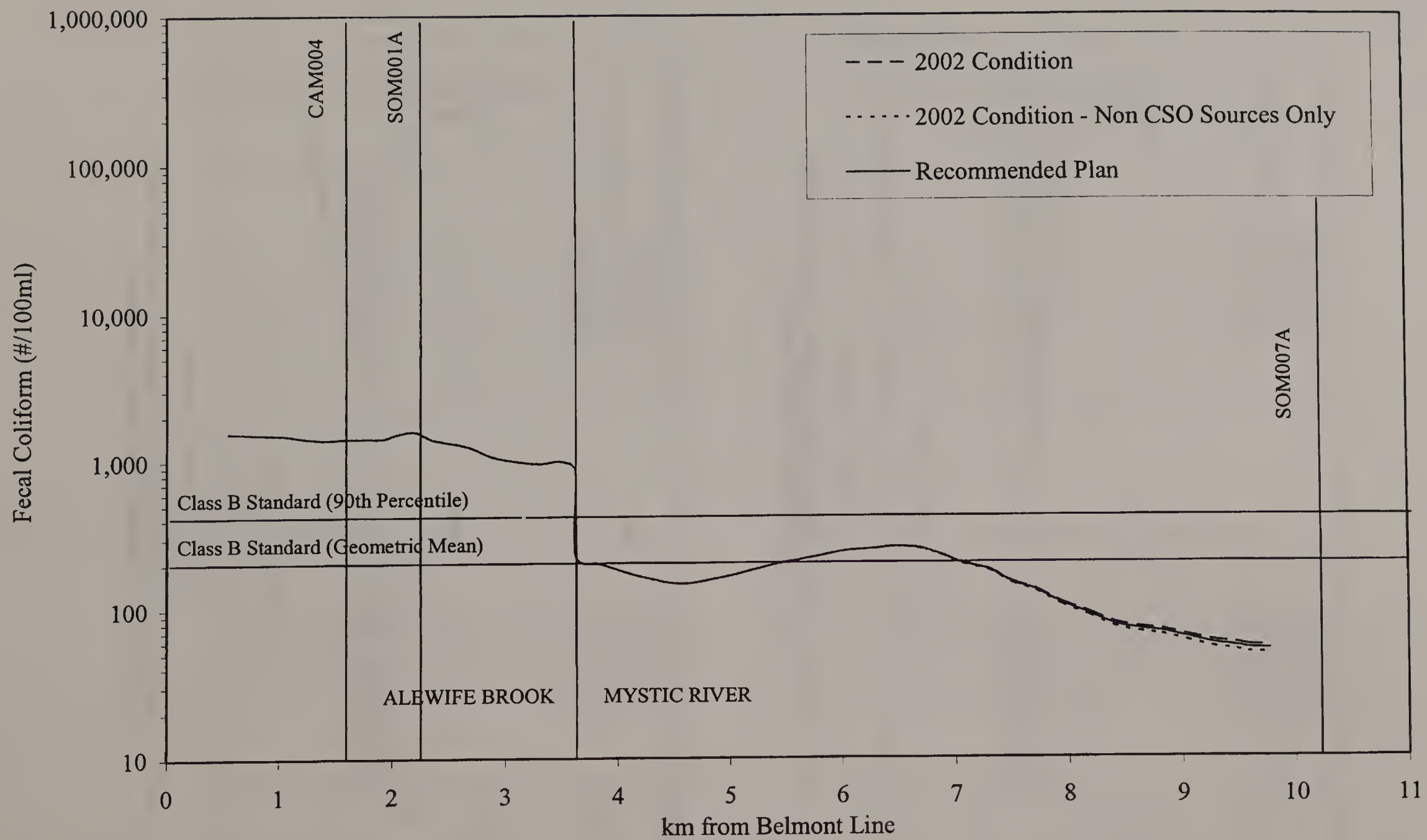


FIGURE 6-20. ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
180 Hours After the Peak of the 1-Year Storm

Brook above the Class B standard in the 1-year storm extends from the peak of the storm to approximately 84 hours after the peak. The impact of non-CSO wet weather sources on attainment of the Class B standard in the Mystic River extends from the peak of the storm to approximately 120 hours after the peak.

Providing a higher level of control in the 1-year storm than provided by Targeted Sewer Separation Alternative A could further reduce the magnitude of the impact of CSO on both Alewife Brook and the Upper Mystic River. It should be noted, however, that the duration of CSO impact in Alewife Brook is approximately six hours or less under Targeted Sewer Separation Alternative A, as compared with the 84-hour duration of impact of non-CSO wet weather sources. These impacts must be further considered in the context of the baseline dry weather condition in Alewife Brook, in which fecal coliform densities in most of the brook exceed the Class B standard.

Based on this assessment, a marginal further reduction in the CSO bacteria load to Alewife Brook in the 1-year storm would have limited benefit in terms of reduction of the magnitude or duration of wet weather impacts. A more substantial further reduction in CSO bacteria load in the 1-year storm would cost at least $38 million more (consolidation to screening and disinfection facility), and would not affect the magnitude or duration of the non-CSO wet weather impacts to Alewife Brook and the Upper Mystic River. As described in Chapter Four, reducing the baseline fecal coliform densities in stormwater by up to 50 percent would not substantially change the conclusions drawn from the receiving water modeling results.

Duration of Class B Criteria Violation/Percent Compliance

In the MWRA's 1997 CSO Facilities Plan, the duration of Class B water quality criteria violation due to CSO impacts was assessed by running the receiving water models with pollutant loads from CSO sources, only. The model was run for the 3-month and 1-year storm, and the duration of violation for each storm was determined. The CSO volumes from the 3-month and 1-year storms were then compared against the volumes from the storms within the typical year for

which CSO discharges were predicted. Storms with CSO volumes less than or equal to the 3-month storm were assigned the duration of violation determined for the 3-month storm. Storms with volumes greater than the 3-month storm, but less than or equal to the 1-year storm, were assigned the duration of violation associated with the 1-year storm. The total predicted hours of violation were then divided by the total number of hours in a year, to determine the fraction of the time that the Class B standards would be violated due to CSO. Subtracting that fraction from 1.00 and multiplying by 100 produced the percent of time the waterbody would be in compliance with the Class B standards if all other sources of pollution were controlled (i.e. CSO would not preclude attainment of the Class B standard).

Under the updated recommended plan for Alewife Brook, the 1-year storm did not produce the largest CSO volume in the typical year, and the 3-month storm did not result in CSO discharges. Therefore, the October 23 storm from the typical year (1992) was substituted for the 1-year storm, and the August 17 storm from the typical year (1992) was substituted for the 3-month storm. The analysis for percent compliance with the Class B fecal coliform standard for CSO loads, only, is presented in Table 6-2.

As indicated in Table 6-2, the October 23 storm, which produced the greatest volume of CSO in the typical year, would have caused 54 hours of violation of the Class B standard if CSO were the only source of pollutants to the Alewife Brook/Upper Mystic River receiving water. The August 17 storm, which produced the third-highest CSO volume, would have caused four hours of violation of the Class B standard at the locations monitored. These values extrapolate to compliance with the Class B standard 98.5 percent of the time, assuming other sources of pollution were controlled.

TABLE 6-2. PERCENT COMPLIANCE WITH CLASS B FECAL COLIFORM STANDARD

Design Storm	Total Rainfall (in.)	Recommended Plan CSO Volume (MG)
5/2/92 from Typical Year	1.14	0.28
8/11/92 from Typical Year	0.87	0.46
8/17/92 from Typical Year	**1.81**	**0.92**
9/3/92 from Typical Year	1.19	0.02
9/9/92 from Typical Year	0.57	0.01
9/22/92 from Typical Year	2.79	2.55
10/23/92 from Typical Year	**1.18**	**3.16**
	Hours of Violation of Class B Fecal Coliform Bacteria Standards, Recommended Plan, CSO Sources Only	
8/17/92 from Typical Year	4	
10/23/92 from Typical Year	54	

Storms with volume <= to 8/17/92 storm: 5

Storms with volume >8/17/92 storm, but <= 10/23/92 storm: 2

(5 x 4 hours) +(2 x 54 hours) = 128 total hours of violation of 200/100ml standard

Annual percent compliance with 200/100ml standard, based on CSO load only:

100 x [1- (128 hours of violation/8,760 hours/year)] = 98.5 percent

The DEP CSO Policy states that:

> Generally, eligibility for Class B_{CSO} status is limited to discharges that can meet national goal use standards more than 95 percent of the time, but the highest level of control must always be achieved for each case as determined in the facilities plan through a cost/benefit analysis.

The receiving water modeling has demonstrated that the current recommended plan for Alewife Brook, Targeted Sewer Separation Alternative A, would meet the definition of minimizing CSO impacts as expressed in the DEP CSO Policy. From the receiving water modeling, it can also be inferred that providing a higher level of CSO control would have limited benefit in terms of achieving national goal uses. Since the more costly alternatives would not result in proportionally greater benefit, the current recommended plan would be considered the highest appropriate level of control based on cost/benefit analysis.

MITIGATION OF REMAINING CSO DISCHARGES

Under the recommended plan, on average CSOs will activate seven times in the typical year, with a total annual volume of approximately 7.3 million gallons. Measures to be taken by MWRA and Cambridge to mitigate these remaining impacts include:

- Providing floatables control at the CSO outfalls to remain open
- Continued implementation of the Nine Minimum Controls and best management practices regarding collection and transport system maintenance
- Implementing a public notification program. On July 2, 2002, MWRA and the cities of Cambridge and Somerville jointly submitted to DEP a Draft Workplan for Public Notification. This draft work plan was submitted in accordance with the conditions of the Extension to the Alewife Brook/Upper Mystic River Variance. DEP held extensive discussions with MWRA, Cambridge, and Somerville and considered comments from watershed groups in the process of finalizing the enhanced public notification program. The key elements of the program are summarized as follows:

1. Maintain existing signage that marks the locations of CSO outfalls.
2. Install new signage at key "put-in" locations; these signs will contain descriptive information about the wet weather impacts on water quality in Alewife Brook/Upper Mystic River and associated public health risks.
3. Issue an annual joint press release with an update of CSO control progress, general water quality information, and information about potential public health risks.
4. Institute a system to provide notification of a CSO activation within 24 hours of the discharge.
5. Update MWRA and municipal websites to include CSO/water quality information and post quarterly CSO activation data.

Upon approval from DEP, MWRA, Cambridge and Somerville intend to implement the Public Notification Workplan.

AFFORDABILITY ANALYSIS

In accordance with the DEP's CSO Policy, one of the requirements for revising the water quality standard for a waterbody from Class B to Class B_{CSO} is that national goal uses must be demonstrated to be met at least 95 percent of the time based on CSO loads, only, and that providing a higher level of CSO control would result in substantial and widespread social and economic impact. The assessment presented above demonstrated that Targeted Sewer Separation Alternative A would allow attainment of the Class B standard more than 95 percent of the time, based on CSO loads, only. The demonstration that providing a higher level of control may cause substantial and widespread social and economic impact is based on an affordability analysis as described below.

This affordability analysis has been prepared in accordance with EPA's *Interim Economic Guidance for Water Quality Standards Workbook*, March 1995. The analysis has been developed for the recommended CSO control alternatives included in MWRA's fiscal year (FY) 2004 capital expense budget, which includes the cost of Targeted Sewer Separation Alternative A for the CSO control plan for Alewife Brook. The assessment looks at rates in FY 2010 which begins

in July of calendar year (CY) 2009, as that is the year in which rate increases related to the current capital expense budget are expected to peak.

EPA's affordability analysis consists of an assessment of substantial impacts, and if impacts are found to be substantial, a determination of widespread impacts. The assessment of substantial impacts consists of two elements: the Preliminary Municipal Screener, which considers the annual pollution control cost per household, and the Secondary Test, which evaluates a range of financial indicators for the impacted community. The determination of widespread impacts may consider the relative magnitude of financial indicators such as data related to unemployment, changes in household income, losses to the local economy, decreases in tax revenues, indirect effects on other businesses, increases in sewer fees for private entities, and other relevant factors.

The assessment of substantial and widespread impacts was conducted for three communities in the MWRA service area: Boston, Chelsea, and Cambridge. Boston represents the largest of the communities in the MWRA service area; Chelsea represents the community with the lowest median household income; and Cambridge is the community in which the currently proposed CSO project for the Alewife is proposed. The individual assessments for the cities of Boston, Chelsea and Cambridge are included in the Appendix. In addition, the discussion of potential substantial and widespread impacts also addresses the effects that increased rates would have on other MWRA service area communities.

Municipal Screener

The median household income (MHI) value is critical to the determination of affordability. A value for the MHI was obtained from 2000 U.S. Census Bureau data for Boston, Chelsea, and Cambridge which reports data from the year 1999. In 1999, the MHI for the city of Boston was $39,629; the MHI in the city of Chelsea was $30,161; and the MHI in the city of Cambridge was $47,979. Using the Consumer Price Index (CPI) through 2001 and an estimated escalation rate

of 2.5 percent per year in the years 2002-2009, these values increase to $52,592, $40,027, and $63,674 in 2009 for Boston, Chelsea, and Cambridge, respectively.

Planned costs for wastewater and water service are also critical to the determination of affordability. The MWRA planning estimates of future costs and charges reflect the final FY 2004 Current Expense Budget (including the impacts on the budget and on community charges of the FY 2003 mid-year rate increase), approved by the Board of Directors in June 2003. The MWRA projects that wholesale charges will increase by 9.2 percent from FY2009 to FY 2010. These charges impact local/municipal charges starting in July 2009.

Assuming annual average household consumption of 61,000 gallons (based on actual water consumption as reported to the Massachusetts Department of Environmental Protection), the Authority is assuming average rates in CY 2009 will be $463 for sewer service and $320 for water service, for a combined rate of $783. (Note, this is a weighted average for all MWRA communities and includes municipal costs for services as well as the Authority's wholesale charges.) In previous evaluations addressing the rates in MWRA's service area, the basis of the rate projection was an industry standard of 90,000 gallons per household per year. The average residential household rate in CY 2009 at this higher usage volume would be $684 for sewer service and $472 for water service. Combined water and wastewater service would be $1,155.

Table 6-3 summarizes the results of the Preliminary Municipal Screener analyses for the cities of Boston, Chelsea, and Cambridge in CY 2009 under both the 61,000 and 90,000 gallons per year usage scenarios. As shown in Table 6-3, the wastewater costs alone in Boston and Cambridge at the 61,000 gallons per year usage rate represent lesss than one percent of MHI. However, the combined cost of wastewater and water in these communities represents approximately 1.3 percent of MHI. The cost per household in Chelsea is higher, where wastewater costs alone represent 1.2 percent of MHI, and combined costs of wastewater and water represent 1.9 percent of MHI. The costs per household are higher in all three communities if the industry standard of

TABLE 6-3. SUMMARY OF PRELIMINARY MUNICIPAL SCREENER FOR BOSTON, CHELSEA, AND CAMBRIDGE

	(61,000 gpy)		(90,000 gpy)	
	Annual Household Cost	**Percent of Median Household Income**	**Annual Household Cost**	**Percent of Median Household Income**
Boston 2009 Wastewater Costs	$397	0.8%	$616	1.2%
Boston Combined 2009 Water and Wastewater Costs	$687	1.3%	$1,056	2.0%
Chelsea 2009 Wastewater Costs	$467	1.2%	$725	1.8%
Chelsea 2009 Combined Water and Wastewater Costs	$758	1.9%	$1,167	2.9%
Cambridge 2009 Wastewater Costs	$484	0.8%	$750	1.2%
Cambridge Combined 2009 Water and Wastewater Costs	$827	1.3%	$1,272	2.0%

90,000 gallons per year is used. Under this scenario, wastewater costs alone in Boston and Cambridge rise to 1.2 percent of MHI while combined water and wastewater costs rise to 2.0 percent of MHI. Impacts in Chelsea are even greater with wastewater costs alone rising to 1.8 percent and combined water and wastewater costs rising to 2.9 percent of MHI.

A substantial number of other communities in the MWRA service area also bear costs of water and wastewater service approaching or exceeding 1.0 percent of MHI. More than half (53 percent) of the 43 communities in the service area bear combined water and wastewater costs representing more than 1.0 percent of MHI at a usage rate of 61,000 gallons per year. This number increases substantially when the industry standard of 90,000 gallons per year is used. Combined water and wastewater costs represent greater than one percent in 86 percent of the 43 communities.

It must be emphasized that the costs that are incorporated in the capital expense budget on which the rates are set do not include several other substantial programs that the MWRA may have to implement. The Authority's *Capital Improvement Program and Budget* continues to evolve and new projects, maintenance needs, and cost increases may be incorporated into the capital improvement program. The MWRA is currently developing a methodology to prioritize future capital spending on wastewater interceptor rehabilitation and replacement projects to maintain and update its built assets so that MWRA can provide reliable wastewater services and protect public health and the environment. Based on an analysis of age and pipe materials along with data from ongoing inspection programs, MWRA expects to significantly increase annual capital expenditures for interceptor renewal in order to maintain and upgrade the existing system. While the methodology has not been finalized, previous studies by MWRA have projected estimated future spending to be approximately at least $20 million per year for a minimum of the next 10 years, simply to deal with the pipe in the poorest condition and continuing expenditures thereafter.

Additional system rehabilitation and replacement needs can be expected to be added, as projects are better developed and defined. Among these projects are the following:

- Repair or rehabilitation of existing headworks and pump stations at an estimated annual cost of $10 million to $17 million.
- Additional treatment requirements at the Walnut Hill Water Treatment Plant.
- Additional rehabilitation or repair of water aqueducts including the Quabbin Tunnel, Sudbury Aqueduct, and Weston Aqueduct.
- Metropolitan Tunnel Loop redundancy.
- Projects to meet new mandates for infiltration and inflow reduction.

Individual community costs may also increase substantially due to local improvements. For example, costs (and associated local rates) in Cambridge would be expected to increase as the city share of the Alewife CSO control project is incorporated into the city's capital improvement program.

The implication of implementation of any of these projects should be considered when assessing the potential burden on rate payers. While the MWRA CIP includes many projects required to meet the Federal Clean Water Act, Safe Drinking Water Act, and state regulations, MWRA expects to receive no grant funding in support of these projects.

Since FY 1992, MWRA has received debt service assistance from the Commonwealth of Massachusetts. In FY 2003, funding for debt service assistance was eliminated by the Commonwealth, requiring the first mid-year assessment adjustment by MWRA.

MWRA planning estimates assumed at least $50 million in debt service assistance each year. For FY 2004-FY 2013 the loss of debt service assistance will require MWRA to raise at least an additional $500 million dollars in rate revenue from member communities. Current household cost projections assume no debt service assistance.

It is important to note that MWRA has worked very hard to keep rate increases to a reasonable level while still implementing improvements to meet regulatory requirements. This means that very difficult decisions on priorities have been made in developing the capital improvement program budget. However, while MWRA has made every effort to control rate increases, it still ranks near the top in a comparative survey of residential water and sewer charges for major U.S. cities. A survey conducted by the MWRA Advisory Board comparing 2002 rates for comparable water and wastewater usage showed MWRA ranked third highest out of 27 cities. Of the cities surveyed, only Seattle, Washington and Portland, Maine, with total combined annual charges of $963.50 and $859.68, respectively, ranked higher than the MWRA which had an annual combined cost of $796.71.

Thus, it is evident that the cost of wastewater and water service to the residential ratepayers of Boston, Chelsea, and Cambridge, as well as the residential ratepayers in a significant number of the other communities in the MWRA service area, will continue to represent a substantial burden on median household income.

Secondary Test

The second component of the substantial impacts assessment is consideration of secondary information on the economic health of the communities. Attachments A, B, and C in the Appendix present the secondary data for Boston, Chelsea, and Cambridge, respectively. The appropriate EPA worksheets are presented for each community.

The results of the secondary test indicate that Boston has an average score of 2.2, indicating that it falls in the mid-range category; Chelsea has an average score of 1.4, indicating that it falls in the weak category; and Cambridge has an average score of 2.2, and thus also falls in the mid-range category. It is important to note that the indicator of property tax revenues as a percentage of full market value of taxable property is not a valid economic indicator in Massachusetts due to the limitations of Proposition 2 ½. Proposition 2 ½ effectively limits the amount a community can raise from property taxes to 2 ½ percent of market value. Both the cities of Boston and Chelsea have been very close to the limit in both FY 2001 and FY 2002, and they both rely heavily on state aid to meet annual budget requirements. In FY 2002, state aid receipts to the city of Boston totaled $581.9 million, or approximately 31 percent of the total budget. In Chelsea, the city relied on state aid for 55 percent ($62.2 million) of its FY 2002 budget. The heavy reliance of these cities on state aid is very problematic because aid can be variable from year to year. In fact, the current decline in the state's economic health is having serious consequences in both communities. Cambridge, however, does have excess capacity under Proposition 2 ½. In FY 2002 Cambridge had 16.3 percent excess capacity, up from 13 percent in FY 2001.

The preliminary screener and the secondary test score are applied to EPA's Substantial Impacts Matrix, shown below. According to EPA's guidance, "X" indicates that the impact is likely to be substantial. A "√" indicates that the impact is not likely to be substantial. The "?" indicates that the impact is unclear. Given that the secondary score in the city of Boston is 2.2, implementation of the recommended CSO plan in Boston based on wastewater costs alone (based on use of 61,000 gallons per year) would fall in the middle cell of the left column of the matrix, indicating

that the impact of implementation of the recommended CSO control plan is not likely to be substantial. Based on wastewater and water costs combined (based on use of 61,000 gallons per year) impacts would fall in the middle cell of the middle column of the matrix indicating that the impact of implementation is unclear, but could be potentially substantial.

For the city of Chelsea, the secondary score is 1.4, and implementation of the recommended CSO plan based on wastewater costs alone or water and wastewater costs combined (based on use of 61,000 gallons per year) would fall in the top cell of the middle column of the matrix, indicating that the impact of implementation would be substantial. For the city of Cambridge the maximum secondary score is 2.2, and impacts of the wastewater program based on wastewater costs alone (based on use of 61,000 gallons per year) would fall in the middle cell of the left column of the matrix, indicating that the impact of implementation of the recommended CSO control plan is not likely to be substantial. Based on wastewater and water costs combined (based on use of 61,000 gallons per year) impacts would fall in the middle cell of the middle column of the matrix indicating that the impact of implementation is unclear, but could be potentially substantial.

TABLE 6-4. EPA ASSESSMENT OF SUBSTANTIAL IMPACTS MATRIX

Secondary Score	Municipal Preliminary Screener		
	Less than 1.0 Percent	Between 1.0 and 2.0 Percent	Greater than 2.0 Percent
Less than 1.5	?	X	X
Between 1.5 and 2.5	√	?	X
Greater than 2.5	√	√	?

The potential for substantial impact on residential ratepayers becomes more definitive when the rates are projected at higher usage (industry standard of 90,000 gallons per year). Under these projections, the cities of Boston and Cambridge both fall into the middle row of the middle column when considering wastewater costs only, indicating that a substantial impact could be incurred. However, when considering combined costs of water and wastewater, the city of Chelsea moves from the top cell in the middle column to the top cell in the right column.

These findings indicate that the residents of Chelsea will incur a substantial impact and that the residents of both Boston and Cambridge could potentially incur a substantial impact as a result of implementing the recommended CSO program. Attachments A, B, and C provide supporting data for the determination of the secondary test and provide some additional information for the determination of widespread impact in these communities.

It is important to note that while this analysis primarily addresses the communities of Boston, Chelsea, and Cambridge, a significant number of other communities in the MWRA service area are financially strapped due to the deteriorating economic climate in the state. These factors are described in more detail below.

Supplemental Information to Support Determination of Widespread Impact

The information presented below provides an overview of the economic climate in Massachusetts, with emphasis placed on eastern Massachusetts and the Greater Boston area. The communities in the MWRA service area have been greatly affected by the changing economic health of the state.

Housing. Between 1995 and 2000, average housing prices in Massachusetts increased an estimated 49 percent. This increase far surpassed the 12 to13 percent nominal income growth for the same period (Sum et. al, 2001). This disparity has led to a significant housing affordability problem in the state, particularly in eastern Massachusetts where housing sale prices have experienced the strongest growth (Sum et. al, 2001; The Warren Group, 2003).

Labor Force and Unemployment. Based on data from the National Bureau of Economic Research, Massachusetts lost approximately 111,400 jobs between January 2001 and December 2002. This amount was the fifth largest number of jobs lost out of all 50 states during this period, and Massachusetts ranked first in the nation (tied with Georgia) for relative job loss with

a 3.3 percent decline in employment levels (Harrington et. al, 2003). As a result, unemployment rates in Massachusetts have increased. Between 2000 and 2002, the state's unemployment rate increased from 2.6 percent to 5.8 percent (MA DET, 2003). The shrinking pool of employment opportunities paired with the increasing number of unemployed workers has led to the increase of the average duration of unemployment for a typical unemployed individual, increasing from 10.6 to 17.8 weeks between 2000 and 2002 (Sum et. al, 2003).

The majority of the state's increases in unemployment levels is concentrated in eastern Massachusetts. For instance, Boston and the suburban Greater Boston area accounted for 67 percent of unemployment increases for the state between the third quarter of 2000 and the third quarter of 2001 (Harrington et. al, 2001).

Income. Residents of Massachusetts have witnessed a 3.6 percent decline in per capita income between 2000 and 2002. This decline is seven times greater than that for the nation (0.5 percent) over the same period (Sum et. al, 2003).

Between 1989 and 1999, the median real household income in Massachusetts dropped by nearly 10 percent. While the 1998-1999 median household income (MHI) for Massachusetts was 8.6 percent above the nation's MHI, the state's cost of living was estimated to be 10 to 26 percent higher than the national average for the same period. Thus, the income advantage of the typical household in Massachusetts is essentially eliminated (Sum et. al, 2001).

State and National Aid. Since 2001, trends have indicated a growing need for state and national aid by residents of Massachusetts. For example, after experiencing a 63 percent decrease of Temporary Assistance to Needy Families (TANF) caseloads between 1994 and 2000, the number of TANF caseloads in Massachusetts has increased approximately 12 percent since the onset of the state recession in early 2001 (Sum et. al, 2003). The TANF is a cash public assistance program created by the Personal Responsibility and Work Opportunities Reconciliation Act. A

similar trend exists for Food Stamp caseloads in Massachusetts. From 1994 to 2000, the number of Food Stamp caseloads decreased 42 percent. However, since 2001, Food Stamp caseloads in Massachusetts have increased 22 percent.

Meanwhile, MWRA member communities are facing unprecedented cuts in their fiscal years 2003 and 2004 state aid that may result in reductions or elimination of basic services such as health, education, police and fire protection.

Conclusion

As the state's budget process for FY 2004 nears completion, additional information on impacts for MWRA's service area and municipal customers should become available. The MWRA anticipates continuing to update its presentation of the affordability analysis in the coming months and expects to reflect the most recent data in affordability analysis presentations in the several CSO program related reports to be filed in the fall and winter. However, based on the community,state and national data currently available, it is clear that households in the MWRA service area already bear some of the highest rates for water and wastewater service in the country. The pressure to increase rates will contribute to greater burden on residential households that are also facing serious financial realities due to the recent downturn in the state's economy.

NON-MONETARY FACTORS

To complete the comparison of alternatives, Table 6-5 presents a matrix of non-monetary factors associated with each alternative, along with a relative rating for each factor, and an overall relative rating, representing the sum of the individual ratings. The ratings (+, 0, and -) were assigned based on the descriptions of the non-monetary factors presented for each alternative. As applied, the ratings are relative, with + signifying that the alternative is better than others for the

TABLE 6-5. RATING OF NON-MONETARY FACTORS FOR CSO CONTROL ALTERNATIVES

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Complete Sewer Separation	Short-Term Siting Impacts	Construction-related impacts along most streets in the tributary areas. Feasibility of siting facilities to mitigate high flow rates and volumes on Alewife Brook uncertain.	-	-1
	Long-Term Siting Impacts	Potential long-term impact of multiple detention/retention facilities to mitigate impacts of high flows on Alewife Brook.	-	
	O&M Considerations	Marginally reduced run time for pumps at Alewife Brook Pump Station and North Main Pump Station	+	
Consolidation/Storage Conduit	Short-Term Siting Impacts	Construction-related disruptions at main mining shaft near MBTA station for duration of construction, and periodic disruptions at equipment removal shaft, dropshaft and diversion structure locations along Alewife Brook	0	0
	Long-Term Siting Impacts	Relatively small pump-out facility at downstream end may fit below grade. Odor control facility at upstream end likely to be above grade. Public opposition to siting is likely, and identification of suitable sites will be difficult.	0	
	O&M Considerations	Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required	0	

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Consolidation to Storage Tank	Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, and at jacking and receiving shafts dropshafts and diversion structure locations along Alewife Brook	-	-3
	Long-Term Siting Impacts	Tank and pumping equipment would be below grade, but tank odor control facility likely to be above grade. Odor control facility at upstream end likely to be above grade. Public opposition to siting of tank and upstream odor control facility is likely, and identification of a suitable site will be difficult.	-	
	O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required	-	
Consolidation to Primary Treatment (similar to MWRA's Cottage Farm CSO Facility)	Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, and at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook	-	-3
	Long-Term Siting Impacts	Tank and pumping equipment would be below grade, but tank odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end likely to be above grade. Periodic chemical deliveries required. Public opposition to siting of tank and upstream odor control facility is likely, and identification of a suitable site will be difficult.	-	
	O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.	-	

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Consolidation to Screening and Disinfection (similar to MWRA's Somerville Marginal CSO Facility)	Short-Term Siting Impacts	Construction-related disruptions at screening/disinfection facility site near MBTA station, and at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook	-	-3
	Long-Term Siting Impacts	Screening and pumping equipment would be below grade, but odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end likely to be above grade. Periodic chemical deliveries required. Public opposition to siting is likely, and identification of a suitable site will be difficult; may require detention/retention facilities to mitigate peak treated CSO flows.	-	
	O&M Considerations	Cleanup of screening facility required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.	-	

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Consolidation/Storage Conduit with Targeted Sewer Separation	Short-Term Siting Impacts	For 0 OF/yr alternative, construction-related disruptions at main mining shaft site near MBTA station for the duration of the construction, and periodic disruption at the equipment removal shaft. For the 2 and 4 OF/yr alternatives, construction-related disruptions at the jacking and receiving shafts. For all alternatives, periodic disruptions at dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.	-	-1
	Long-Term Siting Impacts	Pumping equipment would be below grade, but odor control facility at upstream end of conduit likely to be above grade. Public opposition to siting of shafts and odor control facility is likely, and identification of suitable sites will be difficult. Detention basin/constructed wetland area required to attenuate peak stormwater flows	0	
	O&M Considerations	Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required.	0	

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Consolidation to Storage Tank with Targeted Sewer Separation	Short-Term Siting Impacts	Construction-related disruptions at tank site near MBTA station, at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.	-	-3
	Long-Term Siting Impacts	Tank and pumping equipment would be below grade, but tank odor control facility likely to be above grade. Odor control facility at upstream end likely to be above grade. Public opposition to siting of tank and upstream odor control facility is likely, and identification of a suitable site will be difficult. Detention basin/constructed wetland area required to attenuate peak stormwater flows.	-	
	O&M Considerations	Cleanup of tank required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required	-	

Alternative	Non-Monetary Factor	Description	Individual Rating	Overall Rating
Consolidation to Screening and Disinfection with Targeted Sewer Separation	Short-Term Siting Impacts	Construction-related disruptions at screening/disinfection facility site near MBTA station, at jacking and receiving shafts, dropshafts and diversion structure locations along Alewife Brook, in most streets in the CAM004 and CAM400 tributary areas, and in the vicinity of the intersection of Massachusetts Avenue and Fresh Pond Parkway.	-	-3
	Long-Term Siting Impacts	Screening and pumping equipment would be below grade, but odor control equipment and chemical storage and feed equipment likely to be housed in an above-grade structure. Odor control facility at upstream end likely to be above grade. Public opposition to siting is likely, and identification of a suitable site will be difficult; may require detention/retention facilities to mitigate peak treated CSO flows. Detention basin/constructed wetland area required to attenuate peak stormwater flows.	-	
	O&M Considerations	Cleanup of screening facility required after each activation. Routine maintenance required on equipment; periodic cleaning of accumulated grit in consolidation conduit likely required	-	
Targeted Sewer Separation	Short-Term Siting Impacts	Construction-related impacts along most streets in the tributary areas to be separated (CAM004, CAM400, CAM002 and/or SOM01A, depending on the alternative). Construction-related impacts in Alewife Reservation associated with stormwater wetland/detention basin	0	+1
	Long-Term Siting Impacts	Detention basin/constructed wetland area required to attenuate peak stormwater flows	0	
	O&M Considerations	Marginally reduced run time for pumps at Alewife Brook Pump Station and North Main Pump Station; periodic maintenance on stormwater wetland	+	

non-monetary factor rated, 0 signifying that the alternative is not as good as some but better than others, and – signifying that the alternative is less-suited than others for the factor rated. For example, while construction impacts are inherently undesirable, the localized impacts of targeted sewer separation would be considered less severe than the impacts associated with construction of a consolidation conduit and CSO facility, or complete, area-wide sewer separation. For this reason, the short-term impacts associated with targeted sewer separation were rated as a +, relative to all of the other alternatives. For this level of analysis, the specific level of control for each alternative (0, 2, 4 or more overflows per year) was not considered to affect the relative ratings.

Table 6-6 ranks the alternatives by overall rating. As indicated in Table 6-6, the targeted sewer separation alternative was the highest ranked, followed by the consolidation/storage conduit, complete sewer separation, and the consolidation/storage conduit with targeted sewer separation. All of the alternatives that involved either a storage tank or treatment facility were tied for the lowest ranking.

The major benefits to the targeted sewer separation alternative were that with the exception of the stormwater wetland/detention basin, construction impacts were limited to short-term disruptions to individual streets; no permanent above-grade structures would be required; and there would be no new facility to operate and maintain. The stormwater wetland/detention basin would have short-term construction impacts, and it would be a permanent feature in the Alewife Reservation. The intent of the design of the stormwater wetland/detention basin is that it enhance the current condition of the Reservation. Complete sewer separation would have the benefits of no above-grade structures and no additional O&M, but the construction impacts would be more wide-spread. The construction impacts of the consolidation/storage conduit would be more localized than for sewer separation, but would be for a longer duration in a specific location (the downstream mining shaft). Long term impacts of complete sewer separation would depend on the means determined for attenuating peak stormwater flows.

TABLE 6-6. RANKING OF ALTERNATIVES BY NON-MONETARY FACTOR RELATIVE RATINGS

Alternative	Overall Rating from Table 6-5
Targeted Sewer Separation	+1
Consolidation/Storage Conduit	0
Complete Sewer Separation	-1
Consolidation/Storage Conduit with Targeted Sewer Separation	-1
Consolidation to Storage Tank	-3
Consolidation to Primary Treatment	-3
Consolidation to Screening and Disinfection	-3
Consolidation to Storage Tank with Targeted Separation	-3
Consolidation to Screening and Disinfection with Targeted Separation	-3

DISCUSSION

The cost/performance data presented above indicate that Targeted Sewer Separation Alternative A is the most cost-effective alternative in terms of fecal coliform bacteria, TSS and BOD load removal. To achieve marginally higher levels of removal of these pollutants would require significantly increased cost. The receiving water model data presented above demonstrated that marginally-higher levels of CSO control would not result in significant reductions in the magnitude and duration of wet weather impacts to Alewife Brook and the Upper Mystic River due to non-CSO wet weather sources. The receiving water model, supported by sampling data,

indicates that even in dry weather, the Class B standard is not attained in most of Alewife Brook. The assessment and ranking of alternatives in terms of non-monetary factors also supports selection of targeted sewer separation as an appropriate CSO control alternative for the Alewife Brook/Upper Mystic area.

Based on the affordability analysis presented above, increasing the cost of the CSO control plan for Alewife Brook above the current cost for Targeted Sewer Separation Alternative A would result in substantial and widespread social and economic impact in the city of Chelsea, and could potentially result in substantial and widespread social and economic impact in the cities of Boston and Cambridge. These findings, in conjunction with the cost/benefit analysis, the water quality impact assessment, and the assessment and ranking of alternatives in terms of non-monetary factors, support the selection of Targeted Sewer Separation Alternative A as the recommended CSO control plan for Alewife Brook.

References

Harrington, Paul E., Andrew M. Sum, and Robert MacCready, 2001. Rising Unemployment and Worker Dislocation during the Current Economic Recession in Massachusetts. Center for Labor Market Studies, Northeastern University. Boston, MA. December 13, 2001.

Harrington, Paul E., Andrew M. Sum, and Joseph Moonan, 2003. Revised Wage and Salary Job Counts for States Reveal Much Steeper Job Losses Over Past Two Years: New England and Massachusetts Top the List of Job Losers. Center for Labor Market Studies, Northeastern University. Boston, MA. April 2003.

Massachusetts Division of Employment and Training (MA DET), 2003. Labor Force and Unemployment Data. Available online: http://lmi2.detma.org/lmi/lmi_lur_a.asp.

Sum, Andrew, Sheila Palma, and Ishwar Khatiwada, 2001. "The Story of Household Incomes in the 1990s." The Massachusetts Institute for a New Commonwealth. Policy Brief March 2001.

Sum, Andrew, Ishwar Khatiwada, Jacqui Motroni, and Sheila Palma, 2003. The Impacts of the 2001-2002 Economic Recession in Massachusetts on the Real Weekly Earning of Massachusetts Workers, the Per Capita Incomes of State Residents, and the Caseloads for Key Public Transfer Programs. Center for Labor Market Studies, Northeastern University. Boston, MA. April 2003.

The Warren Group, 2003. Town Stats: Free Market Statistics. Available online: http://rers.thewarrengroup.com/townstats/.

Section Seven

CHAPTER SEVEN

RECOMMENDED PLAN

This chapter summarizes the components of the recommended plan for CSO control for Alewife Brook, followed by a discussion of the incremental benefits of phased implementation of the recommended plan. This chapter concludes with a discussion of why elimination of CSOs to Alewife Brook through sewer separation is not recommended.

SUMMARY OF THE RECOMMENDED PLAN

The following summary of the recommended plan includes a description of the plan and a review of the evaluations supporting selection of the plan; a summary of the proposed implementation schedule for the recommended plan; a summary of the short-term and long-term impacts of the recommended plan; and a description of the stormwater wetland detention basin that will be included as part of the CAM004 sewer separation project.

Description of the Recommended Plan

The elements of the recommended plan are summarized as follows:

- Complete separation of the combined sewer system upstream of regulator RE-041 (outfall CAM004), and closure of the regulator. The scope of this work includes construction of a new stormwater outfall for the CAM004 tributary area, a stormwater wetland/detention area downstream of the new outfall to attenuate flows, and sewer flushing/grit accumulation chambers to control the buildup of sediment in the new pipes.

- Separation of the combined manholes upstream of outfall CAM400.

- Increasing the capacity of the dry weather flow connections between the CSO regulator and the MWRA interceptor for outfalls CAM002, CAM401B and SOM01A

- Providing relief of the siphon between the ABBS and the ABC downstream of the Rindge Avenue combined sewer

- Providing a hydraulic relief gate at outfall MWR003, to relieve the hydraulic grade line during extreme storm events

- Providing floatables control for outfalls CAM001, CAM002, MWR003, CAM400, CAM401A, CAM401B and SOM01A

The total estimated capital cost of the revised recommended plan is $73.7 million. Upon completion of the plan, the average annual activation frequency of CSO discharge to Alewife Brook will be reduced from 63 to 7, and the average total annual volume of CSO will be reduced from 50 to 7.4 million gallons.

The revised recommended plan will result in a net increase in the total volume of stormwater discharged to Alewife Brook on an annual basis, as a result of the sewer separation projects. It is noted, however, that currently approximately 75 percent of the annual stormwater volume tributary to Alewife Brook is from the non-CSO communities of Arlington and Belmont. A comparison of the annual CSO and stormwater volumes from Cambridge and Somerville for existing conditions prior to the start of the Contract 2A/2B construction on Fresh Pond Parkway, and the recommended plan is presented Figure 7-1. Despite the net increase in annual stormwater volume, the bacteria and solids loads from stormwater to Alewife Brook are predicted to decrease (Figures 7-2 and 7-3). The predicted decrease in loads is in part due to the difference in pollutant concentrations between CSO and stormwater, and in part due to measures to be provided by the city of Cambridge to capture sand and grit prior to discharge at either the existing CAM004 outfall or to the proposed stormwater wetland detention basin, and the expected removal of bacteria and additional sand and grit for flow that passes through the detention basin.

From the technology-based assessments presented in Chapters Five and Six, the recommended plan was demonstrated to be the most cost-effective approach to minimizing CSO discharges to Alewife Brook. From the water-quality based assessment presented in Chapter Six, it was concluded that providing a higher level of CSO control would not result in significant reductions in the magnitude or duration of wet weather impacts to Alewife Brook and the Upper Mystic River, due to non-CSO wet weather sources. It was further demonstrated that in dry weather, the Class B standard is not attained in Alewife Brook. With this plan in place, CSOs will not preclude attainment of Class B water quality criteria approximately 98 percent of the time on

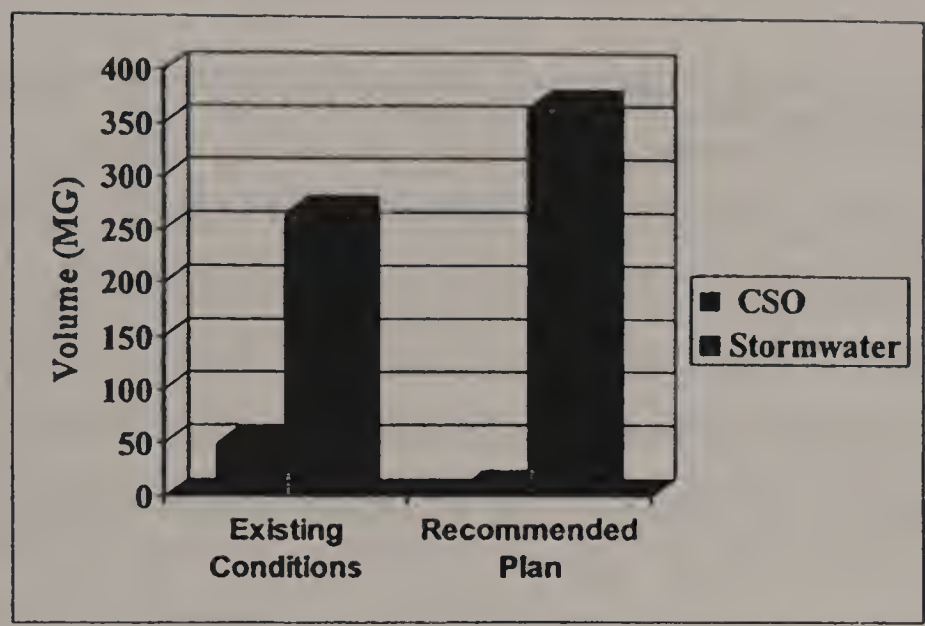


FIGURE 7-1. COMPARISON OF TOTAL ANNUAL CSO AND STORMATER VOLUMES FROM CAMBRIDGE AND SOMERVILLE FOR EXISTING CONDITIONS AND RECOMMENDED PLAN

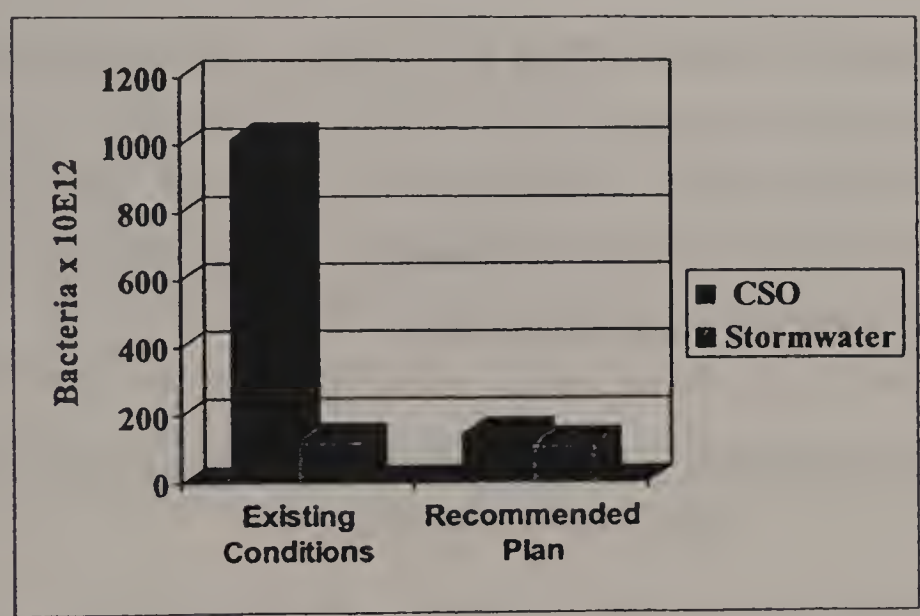


FIGURE 7-2. COMPARISON OF TOTAL ANNUAL CSO AND STORMWATER BACTERIAL LOAD FROM CAMBRIDGE AND SOMERVILLE FOR EXISTING CONDITIONS AND RECOMMENDED PLAN

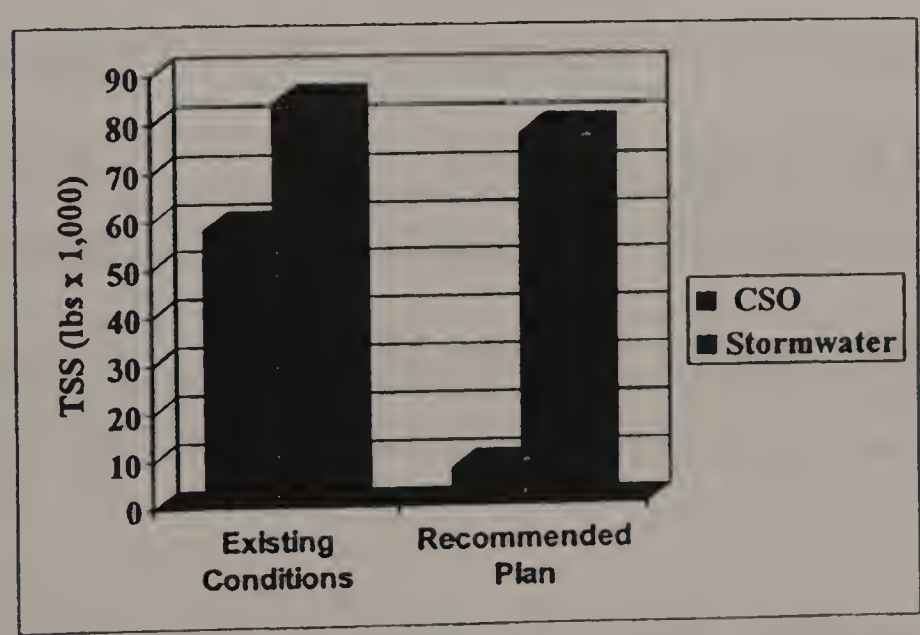


FIGURE7-3. COMPARISON OF TOTAL ANNUAL CSO LOAD AND STORMWATER TSS LOAD FROM CAMBRIDGE AND SOMERVILLE FOR EXISTING CONDITIONS AND RECOMMENDED PLAN

average. Based on the affordability assessment conducted in accordance with EPA guidelines, increasing the cost of the CSO control plan for the Alewife/Upper Mystic basin above the cost of the recommended plan would result in substantial and widespread social and economic impact in the city of Chelsea, and could potentially result in substantial and widespread social and economic impact in the cities of Boston and Cambridge. The analyses presented herein therefore support the revision of the water quality standard for Alewife Brook and the Upper Mystic River to Class B_{CSO}, in conjunction with the implementation of the recommended plan as described herein.

Proposed Implementation Schedule for the Recommended Plan

Table 7-1 presents the proposed implementation schedule for the recommended plan. This schedule has been developed in coordination with the city of Cambridge. The city of Cambridge will implement the recommended plan with funding from the MWRA, and the schedule has been developed based on the capability of the city of Cambridge to implement the work within the context of on-going and scheduled infrastructure work.

TABLE 7-1. PROPOSED IMPLEMENTATION SCHEDULE FOR THE RECOMMENDED PLAN

Project Element	Construction Start	Construction Complete
CAM004 Outfall and Stormwater Wetland/Detention Basin (Contract 12)	July 2005	December 2006
CAM400 Common Manhole Separation	July 2004	April 2005
Interceptor Connection Relief/Ringe Avenue Siphon Relief/MWR003 Gate	July 2005	July 2007
CAM004 Upstream Sewer Separation Contract 9	June 2008	December 2009
CAM004 Upstream Sewer Separation Contract 8	December 2010	February 2012

Summary of Short-term and Long-term Impacts of the Recommended Plan

Table 7-2 presents a summary of the benefits, impacts and proposed mitigation associated with the elements of the recommended plan. Many of the project components have not changed since the project was initially described in the 1995 ENF that was submitted subsequent to the MWRA's 1994 *System Master Plan and CSO Conceptual Plan*. Thus, most of the information this table is the same as presented in the April 2001 *Notice of Project Change for the Long Term Control Plan for Alewife Brook* (NPC). However, for those portions of the project which have been modified as a result of comments on the NPC, corresponding updates to the table are provided; this new/revised text is indicated in italics.

Description of Stormwater Wetland Detention Basin

A stormwater wetland detention basin will be provided by the City of Cambridge to mitigate the peak flows from the CAM004 separation project. The proposed wetland basin will be located in the Alewife Reservation, behind the Alewife MBTA station. As described in the May 2003 *Response to Comments on the Notice of Project Change for the Long Term CSO Control Plan for Alewife Brook* (RTC), the design goals and objectives established for the stormwater wetland were as follows:

- To attenuate stormwater flows to the Little River through the design and construction of an ecologically enhanced wetland system with a storage capacity of 10.3 acre-ft.
- To enhance the quality of the stormwater discharged to the river.
- To provide a stormwater wetland that also functions as habitat for the diverse species of birds and mammals presently utilizing the proposed site.
- To design a treatment system that complements the MDC Master Plan for the Alewife Reservation and Alewife Brook Corridor including the provision of educational and recreational features.
- To maintain the volume of the 100-year floodplain consistent with FEMA and State regulations.

TABLE 7-2. SUMMARY OF BENEFITS, IMPACTS AND MITIGATION FOR NPC PROJECTS

Project	Change That Occurred between 1995 ENF and 2001 NPC	*Change That Occurred Between 2001 NPC and 2003 RTC*	Project Benefits	Short-Term		Long-Term	
				Impacts	Mitigation	Impacts	Mitigation
CAM 004 ♦ Sewer Separation	None. Same as proposed in ENF when Phase I waiver was received	*None. Same as described in the ENF and subsequent NPC.*	Elimination of CAM004 CSO outfall, resulting in water quality improvements due to reduction of CSO discharges to Alewife Brook and protection of Fresh Pond Reservoir from potential contamination associated with former regulator structure.	Traffic, dust, noise	Comply with measures outlined in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects	Minor, short term disruptions for routine maintenance	None
♦ New Stormwater Outfall *and Stormwater Wetland*	New project component due to determination that the existing outfall has insufficient hydraulic capacity	*Modification of design formerly presented in NPC with a proposed stormwater wetland to provide increased storage volume, while enhancing the habitat and recreation value of the site.*	Reduction of flooding in CAM004 tributary area during 10-year storm events and storm events of less intensity	Traffic, dust, noise, wildlife disruption, disruption of access to MDC Reservation	Construction mitigation will include seasonal restrictions, groundwater monitoring, erosion control. Additional enhancements to be coordinated with MDC	Disruption of *4,500* sq. ft. of BVW, *150 L.F. of Bank*, 1,000 sq. ft. of LUW, *4000 sq. ft. in the 25 foot Riverfront Area, 5.8 acre footprint disturbance, existing flood plain filling*; disruption of trails in MDC Reservoir; change to wildlife habitat; addition of stormwater to Little River	Construction of *10.3 acre-foot stormwater wetland to provide water quality treatment and* dampen peak flow discharges, improve stormwater quality and create wetland habitat; *BVW replication area provided; compensatory flood storage provided up to elevation 9.0 (NGVD), additional flood storage of 7.5 acre-feet up to elevation 9.0 (NGVD) provided, recreational enhancement (including improved trails in accordance with MDC Master Plan);* installation of upstream BMP's to reduce TSS and oil/grease
Intensive Conveyance System BMP Program ♦ *Deep Sump Catch Basins with Hoods* ♦ *Grit Pits* ♦ *Catch basin water quality inserts*	*(was not conceived at the time of the NPC)*	*New project component to enhance water quality of additional stormwater discharges to Little River/Alewife Brook*	*Reduction in TSS related pollutants to Little River/Alewife Brook*	*Traffic, dust, noise*	*Compliance with measures outlined in NPDES Phase II Stormwater requirements*	*Minor, short-term disturbance for routine maintenance*	*System wide TSS removals including stormwater wetland exceed DEP Stormwater requirements for new development projects*
In-line Control Structure at Sherman Street/ Pemberton Street	*(was not conceived at the time of the NPC)*	*New project component to reduce peak flow discharges to Little River/Alewife Brook*	*Better utilization of in-system storage*	*Traffic, dust, noise*	*Compliance with DEP Stormwater requirements*	*Minor, short-term disturbance for routine maintenance*	*None*
CAM400 Sewer Separation	New Project Component arising from reassessment of recommended CSO control plan	*None. Same as described in the NPC.*	Water quality improvements due to reduction in CSO activation frequency and volume of outfall CAM400	Traffic, dust, noise	Comply with measures outlined in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects	Minor, short term disruptions for routine maintenance	None
Interceptor Relief Connection at CAM002, CAM401B and SOM01A	CAM002 relief connection proposed instead of CAM002 sewer separation due to increased costs for overall project and determination of cost-effectiveness; relief connection at CAM401B is new project component due to discovery of new outfall; SOM01A relief identified in earlier planning report, but not implemented	*None. Same as described in the NPC.*	Water quality improvements due to reduction of CSO activations, frequency, and volume at CAM002, CAM401B and SOM01A	Traffic, dust, noise	Comply with measures outlined in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects; develop traffic management plan in consultation with MDC, Cambridge, Somerville and Arlington	Minor, short term disruptions for routine maintenance	None

TABLE 7-2 (Continued). SUMMARY OF BENEFITS, IMPACTS AND MITIGATION FOR NPC PROJECTS

Project	Change That Occurred between 1995 ENF and 2001 NPC	*Change That Occurred Between 2001 NPC and 2003 RTC*	Project Benefits	Short-Term		Long-Term	
				Impacts	Mitigation	Impacts	Mitigation
MWR003 Floatables Control and Hydraulic Relief Gate	Floatables control is same as proposed in ENF; hydraulic relief gate is new project component arising from reassessment of recommended CSO control plan	*None. Same as described in the NPC.*	Reduction in floatables and solids discharged to Little River from outfall MWR003; relief of upstream flooding during extreme storm events	Dust, noise, disruption of wildlife and pedestrians in MDC Reservation; work in 100-foot buffer zone and riverfront area	Comply with measures outlined in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects; use sedimentation and erosion controls at limits of construction	Monthly maintenance inspections; minor loss of wildlife habitat and pedestrian disruption	Revegetate disturbed areas and repair trails in accordance with overall landscaping plans
Rindge Avenue Siphon	New project component arising from reassessment of CSO control plan	*None. Same as described in the NPC.*	Water quality improvements due to reduction of CSO activations and volumes at outfall CAM 401B; removal of obstruction in Alewife Brook from abandoned underground pipe.	Dust, noise, disruption of wildlife and pedestrians in MDC Reservation; work in the intermittent stream (regulated as Bank)	Comply with measures outline in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects; use sedimentation and erosion controls at limits of construction.	No long term adverse impacts	None
Floatables Control for Alewife Brook Outfalls (1) CAM002♦ CAM 401A* CAM 401B♦ CAM001* CAM400*		*None. Same as described in the NPC.*	Reduction in floatables and solids discharged to Alewife Brook	Dust, noise, traffic	Comply with measures outlined in MWRA's 1998 Draft Mitigation Guidelines for Phase I waiver projects	Minor, short term disruption for routine maintenance	None

Note – This table is similar to that presented as Table 8-5 (pages 8-105, 8-106 of the NPC). It identifies those changes which occurred between the initial ENF (1995) and the NPC (2001), as well as those changes which have occurred as a result of comments received on the NPC. Changes to project elements that have occurred subsequent to the NPC are indicated by italic text.

(1) Key for Floatables Control Projects:
- ♦ New Project Component
- * Same as Proposed in ENF

- To minimize impacts to bordering vegetated wetlands.

A more detailed description of the wetlands detention basin is provided in the RTC document.

BENEFITS OF INCREMENTAL IMPLEMENTATION OF THE RECOMMENDED PLAN

As indicated above, the current implementation schedule calls for completion of the upstream separation of outfall CAM004 by 2012. It is important to note, however, that significant reductions in CSO activation frequency and volume will be attained before 2012, and in fact, improvements have already been made as a result of on-going construction. Table 7-3 presents a summary of the average annual CSO frequency and volume under conditions prior to the start of construction contracts 2A and 2B along Fresh Pond Parkway, and at key milestones in the implementation of the recommended plan. Contracts 2A and 2B included installation of large-diameter pipe, box conduits and structures along Fresh Pond Parkway, and represented an early phase of the implementation of the original recommended plan. These contracts will also be an integral part of the revised recommended plan. As part of these construction contracts, interim measures were incorporated to reduce the activation frequency of outfall CAM004 until the full scope of separation of the CAM004 area could be completed. These interim measures divert dry weather flow from the upstream combined areas into the new sanitary system constructed along Fresh Pond Parkway. In addition, weirs were constructed at the new Drain Vault No. 5, which replaced the former regulator RE041 structure, to divert significant wet weather combined flows to the interceptor system. As a result of these measures, the predicted annual activation frequency at CAM004 has been reduced from 63 to 14, and the annual volume from 24 to 7.7 million gallons. This improvement at outfall CAM004 has reduced the total annual volume of CSO to Alewife Brook from all outfalls from approximately 50 to 33 million gallons in the typical year.

By 2007, the common manhole separation at CAM400, the interceptor connection relief projects at CAM002, CAM401B and SOM01A, the hydraulic relief gate at MWR003, and the Rindge Avenue relief siphon will be completed. With these projects in place, the total annual CSO activation frequency to Alewife Brook will be further reduced to 13, and the annual volume

reduced to 22 million gallons, a volume reduction of more than 50 percent compared with conditions prior to the start of construction.

DISCUSSION ON WHY CSO ELIMINATION IS NOT RECOMMENDED

Both the state and the national CSO policies indicate that the ultimate goal for CSO control is to attain water quality standards. Where the existing water quality standard is Class B, attainment of that standard requires total elimination of CSOs. It is recognized, however, that attainment of existing water quality standards (i.e., CSO elimination) is not always feasible, and the regulations identify a limited number of specific conditions where a change to water quality standards would be allowed. Among these conditions is where attainment of the standard would cause "substantial and widespread social and economic impact". DEP initially interpreted this clause as meaning where additional expenditures on CSO control would not result in significant improvement in water quality based on cost-effective analyses, provided that remaining CSO impacts are sufficiently minimized. DEP has more recently indicated that the measure of substantial and widespread social and economic impact must include an affordability assessment in accordance with EPA guidelines. While the analyses presented in the preceding chapters demonstrated both the cost-effectiveness of the recommended plan, and the potential impact of more costly controls on affordability, it was clear from the public meetings conducted during the development of the NPC that additional discussion on why CSO elimination was not recommended for Alewife Brook would be useful. To expand upon the analyses presented in earlier chapters, the reasons for not recommending elimination of CSOs to Alewife Brook can be summarized under three categories: total cost, practical implementation issues, and cost/benefit considerations.

TABLE 7-3. SUMMARY OF PERFORMANCE OF INCREMENTAL IMPLEMENTATION OF TARGETED SEWER SEPARATION ALTERNATIVE A (RECOMMENDED PLAN)

Outfall	Existing Conditions Prior to Contract 2A/2B Construction		Existing Conditions Based on Current Status of Contract 2A/2B Construction[1]		Incremental Implementation of Sewer Separation Alternative A, without Contracts 8 and 9[2]		Sewer Separation Alternative A	
	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)	Annual Frequency	Annual Volume (MG)
CAM001	1	0.01	0	0.00	5	0.02	5	0.20
CAM002	7	1.57	7	1.52	5	0.95	4	0.72
MWR003	1	0.06	1	0.05	4	0.62	5	1.03
CAM004	63	24.1	14	7.69	13	12.67	0	0.00
CAM400	10	0.80	10	0.78	0	0.0	0	0.0
CAM401A	7	2.74	7	2.77	5	1.77	5	1.65
CAM401B	25	10.5	25	10.7	8	2.98	7	2.24
SOM01A	10	9.89	10	9.90	6	2.37	3	1.29
Totals	**63**	**49.7**	**25**	**33.4**	**13**	**21.6**	**7**	**7.4**

Notes on Table 7-3:

(1) As part of the Contract 2A/2B construction, interim measures were incorporated to reduce the activation frequency of outfall CAM004, until the full scope of separation of the CAM004 tributary area can be completed. These interim measures divert dry weather flow from the upstream combined areas into the new sanitary system constructed along Fresh Pond Parkway. In wet weather, flow up to the capacity of the new sanitary system is conveyed directly to the interceptor system. Excess flows are conveyed via the new large conduits in Fresh Pond Parkway to Drain Vault No. 5, where temporary weirs have been installed to divert additional wet weather flow to the interceptor. As indicated in Table 1, these interim measures reduce the predicted annual discharge frequency at outfall CAM004 by more than 75 percent, and the annual discharge volume by almost 70 percent.

(2) This condition includes the interim measures constructed under Contracts 2A/2B described under Note 1, along with increasing the size of interceptor connections at CAM002, CAM401B and SOM01A; sewer separation of CAM400; and completion of the Rindge Avenue CS Siphon Relief (basically all elements of Partial Sewer Separation Alternative A, except for the sewer separation work in the upstream CAM004 area).

Total Cost

In Chapter Five, Table 5-5 indicates that the difference in cost between complete sewer separation, and separation of just outfalls CAM004 and CAM400 is on the order of $113 million. As demonstrated by the affordability analysis in Chapter Six, the current cost of the CSO program is projected to have substantial and widespread social and economic impact within at least a subset of the MWRA member communities. Increasing the cost of the program for Alewife Brook by $113 million would worsen this impact. Based on the documentation provided herein, it would be difficult for the MWRA's Board of Directors to justify that magnitude of additional impact to the rate payers in its 43 member communities.

Practical Implementation Considerations

While it is understood that many implementation issues can be overcome with higher cost, three implementation issues bear further discussion. First, in order to eliminate CSO outfalls, a sufficient degree of stormwater inflow must be removed from the collection system so that closure of the outfall will not cause flooding in extreme storm

events. In certain parts of Boston, it has been observed that the roof drains for multi-story, flat-topped buildings may connect with the interior building plumbing. Removing this source of inflow would require changing the interior building plumbing, which would be extremely expensive and time-consuming. It is also not clear that a municipality or other public agency would have the authority to conduct this work and/or mandate and document that it had been conducted by the building owner. It is not known how many buildings in the combined sewer areas tributary to Alewife Brook would fall into this category, but the degree of achievable sewer separation is a key issue in assessing the technical feasibility of eliminating CSOs.

A second implementation issue pertains to the CAM401A/B tributary area. This area is very flat, and the existing sanitary, combined and storm drain piping is highly inter-connected. One of the reasons for the degree of interconnections is the combination of limited available depth of the pipes given the flat topography, the need for a minimum depth of soil cover over the pipes, and the need for the pipes to drain by gravity either to the MWRA interceptors or to Alewife Brook. It is not clear how a new system of storm drains and sanitary piping would be installed in this area given the need to maintain existing flows. At a minimum, significant bypass pumping would be required, which would further increase the cost of separation in this area. It may even be determined that new stormwater and sanitary pump stations would be required, which would again further increase costs and add siting issues as further complexities to be considered.

The third implementation issue draws on the issues associated with separation of the CAM004 area, in particular the limited conveyance capacity of the existing collection system and the need to attenuate flows to Alewife Brook. The capacity of the existing CAM401A outfall to convey combined sewer flows to Alewife Brook is limited to approximately the same degree as the existing CAM004 outfall, if not more so. The extent of the CAM401 combined tributary area to be separated would be approximately on the same scale as the currently-proposed CAM004 area (approximately 250 acres). It would therefore be expected that a new stormwater outfall approximately on the same scale as the proposed CAM004 outfall would be required in order to convey separated

stormwater flows from the CAM401 area to Alewife Brook. Similarly, it would be expected that the need to attenuate peak flow rates and velocities in the new outfall would be similar to the need at outfall CAM004.

The city of Cambridge has indicated that it may be possible to separate the CAM002 tributary area without increasing the conveyance capacity to Alewife Brook. The ability of the existing Tannery Brook Drain to carry separated stormwater flows from the area upstream of outfall SOM01A has not been assessed, but it should be noted that the total combined sewer tributary area upstream of outfall SOM01A is approximately 280 acres. Thus, even if a new outfall were not required, the peak flows and velocities from the Tannery Brook Drain would certainly need to be attenuated.

It is not at all clear how the additional peak stormwater flows from the CAM401 and SOM01A areas would be attenuated to avoid exacerbating bank erosion and downstream flooding, given the scale of the detention basin needed to attenuate the flows from the CAM004 tributary area. It seems that this issue goes beyond one of cost, to a question of the physical availability of space required to provide such attenuation. Without a feasible means to attenuate these flows, complete sewer separation along Alewife Brook is not implementable.

Cost-Benefit Considerations

Elimination of CSO by sewer separation, if implementable, would mean that CSOs would no longer contribute to exceedance of the Class B water quality criteria in Alewife Brook during wet weather. The receiving water model, supported by recent sampling data, indicates that the current quantity and quality of stormwater tributary to Alewife Brook causes substantial exceedence of the Class B criteria for bacteria. Approximately 75 percent of the total annual stormwater runoff volume tributary to Alewife Brook comes from the non-CSO communities of Belmont and Arlington. Even if the additional stormwater discharge resulting from sewer separation in Cambridge and Somerville could in some way be treated, such as by the constructed wetlands proposed for the new

CAM004 outfall, the remaining untreated stormwater from Belmont and Arlington would continue to cause exceedances of the Class B criteria. Further, the monitoring data indicate that the Class B bacteria criteria are exceeded continuously during dry weather.

The conclusion to be drawn from these observations is that CSO elimination by sewer separation, at an incremental cost of at least $113 million beyond the cost of the recommended plan, will not result in attainment of the Class B standard. While there may be value in the knowledge that combined sewage no longer discharged to Alewife Brook during wet weather, consideration must be given to how resources can most effectively be spent to affect the greatest improvement in water quality. It is possible that some fraction of the day-to-day dry weather bacteria load to Alewife Brook is caused by cross-connections between the sanitary sewer system and separate storm drains directly tributary to Alewife Brook and/or the Little River. It is suggested that if additional resources were to be spent on Alewife Brook beyond the cost of the recommended plan, the target of those resources should be the sources causing both the non-CSO wet weather violations and the day-to-day exceedances of the bacteria standard, as opposed to further reducing the activations of CSOs in larger and less-frequent storm events. These activities would appropriately start to move beyond the scope of the MWRA's CSO control program, and introduce the need for engagement and participation of other entities that are responsible for the discharge of flow to Alewife Brook.

Appendix A

Appendix A

APPENDIX A

VARIANCE DOCUMENTS

3/5/99
FINAL
Variance for CSO Discharges to
the Alewife/Upper Mystic Basin

Introduction

In its December 31, 1997 Administrative Determinations for Certain CSO - Impacted Waters, the Department of Environmental Protection (DEP) granted a Variance under its Surface Water Quality Standards at 314 CMR 4.00 for the CSO discharges to the Alewife/Upper Mystic Basin. This Variance is a short-term modification in water quality standards, granted within the context of the NPDES/MA permit. It provides additional time for DEP, EPA, MWRA and others to investigate sources of discharges and to conduct analyses to determine the potential for additional water quality improvements from higher levels of CSO treatment or remediation of stormwater discharges to the Alewife/Upper Mystic Basin.

The Department granted this Variance based on its findings, as supported by the current information, demonstrating that more stringent CSO controls would result in substantial and widespread economic and social impact as specified in 314 CMR 4.03(4).

DEP is formalizing the granting of the Variance for CSO discharges to the Alewife/Upper Mystic Basin by issuance of this Final Variance and associated Variance Conditions. This Variance shall remain in effect from the date of formal issuance, March 5, 1999, for a period of 36 months. During this period, the MWRA, and the Cities of Cambridge and Somerville are required to comply with all of the conditions established by this Variance. At the end of the variance period, or any extension that DEP may determine to be necessary to complete the purposes of this Variance, the Department will review the information provided and determine the surface water quality standard for this basin.

The Variance will be incorporated into the NPDES/MA permits for the MWRA, and the Cities of Cambridge and Somerville, through modification or reissuance during the term of the Variance, with an additional opportunity for public comment. Failure by the MWRA and/or the Cities of Cambridge or Somerville to comply with the conditions of the Variance prior to permit modification or reissuance will constitute a violation of the existing permit, as well as of the Massachusetts Surface Water Quality Standards.

The water quality standard for the Alewife Brook and the segment of the Upper Mystic River (outlet lower Mystic Lake to Amelia Earhart Dam) was modified, through the Variance for the CSO discharges <u>only</u>, which are permitted to the MWRA and the Cities of Cambridge and Somerville; other discharges must meet Class B standards. Provided that the MWRA and the cities of Cambridge and Somerville comply with the Variance Conditions, the Variance allows for exceedances from Class B criteria for CSO discharges.

The Variance requires the MWRA, and the Cities of Cambridge and Somerville, to implement any and all CSO control actions related to the Alewife/Upper Mystic Basin as described in the MWRA's Combined Sewer Overflow Final Facilities Plan/Environmental Impact Report (FFP/EIR) approved by DEP in its December 31, 1997 correspondence, unless modified and agreed to in writing by DEP.

The information gathering and assessment conditions established by this Variance are designed to require the MWRA and the Cities of Cambridge and Somerville to obtain the information necessary for the Department to determine the appropriate water quality standard and level of CSO control pursuant to the DEP Guidance for Abatement of Pollution from CSO Discharges (dated 8/11/97). The Department anticipates that these receiving waters; the Alewife/Upper Mystic Basin; will eventually be designated Class B(CSO), because the Department has not identified a feasible means to completely eliminate all CSOs in this Basin. Information generated during the term of the variance will be used to determine the number and treatment of overflows based on the relative costs and benefits of additional controls where CSOs have not been or will not be eliminated.

The Variance conditions are also designed to require the MWRA and the Cities of Cambridge and Somerville to gather and provide data on stormwater pollutant loads to the segment, in order to assist DEP and EPA to assist in determining whether additional CSO or stormwater controls will yield greater benefits for their relative costs and whether additional control of both CSOs and stormwater is appropriate. Although the MWRA will be gathering and assessing data under the Variance conditions, the responsibility for remediation of stormwater impacts ultimately remains with the various municipal, industrial, commercial, or other stormwater dischargers. That notwithstanding, the MWRA would not be precluded from voluntary participation.

In support of the final determination of required CSO controls and the associated water quality standard, DEP will utilize information included in the 1997 MWRA CSO Facilities Plan, all data and information gathered pursuant to conditions of this variance, and any other credible water quality data or other information gathered under other initiatives, by such groups as EOEA Mystic River Watershed Team.

Conditions Established By and Enforceable Through the Variance

The Department of Environmental Protection requires the MWRA, and the Cities of Cambridge and Somerville to fulfill these requirements as conditions of the Variance:

A. Actions to Minimize CSO/Sanitary Discharges

(1) The MWRA, and the Cities of Cambridge and Somerville shall fully implement the Nine Minimum Controls in accordance with their respective documentation filed with EPA.

(2) For CSOs which discharge to Alewife Brook and the Upper Mystic River, MWRA and the Cities of Cambridge and Somerville shall provide estimates of CSO activations and volumes over the period of this Variance, as follows.

i. The MWRA shall provide to EPA and DEP, on a quarterly basis, estimates of CSO activations and CSO volumes for ALL CSO outfalls to the Alewife/Upper Mystic Basin. By June 1, 1999, the MWRA shall submit to EPA and DEP a plan for achieving compliance with this requirement; using a combination of meters and flow estimates.

ii. The City of Cambridge shall provide to DEP and EPA, on a quarterly basis, a report on its CSO activations and volumes, based on metered data at each of the CSO outfalls.

iii. The City of Somerville shall provide to EPA and DEP, on a quarterly basis, estimates of the CSO activations and volumes from all of their permitted discharges. By June 1, 1999, the City shall submit to DEP and EPA a plan for achieving compliance with this requirement, using a combination of metering and flow estimates.

(3) The MWRA shall reevaluate the possibility of additional Infiltration/Inflow (I/I) controls in the North sewer system at key locations (to be determined by the MWRA in consultation with EPA/DEP and relevant municipalities) as a means to further mitigate CSO activations, volumes, and durations. The MWRA shall report on the results of this analysis by September 1, 1999.

The MWRA shall update relevant portions of its 1994 Master Plan relative to I/I management, based on actions performed by its member municipalities (discharging wastewater to downstream portions of regional wastewater facilities tributary to CSO overflows) to determine whether additional I/I removal could result in substantive reductions in CSO overflows at a reasonable cost.

(4) By January 1, 2000, the Cities of Cambridge and Somerville shall notify, in writing to the MWRA, DEP and EPA, whether they have found conditions within their combined sewer systems that are significantly different than those assumed to exist when the MWRA performed its SOP Program; and where implementation of additional SOP-type actions are likely to provide for significant reduction in CSO discharges. By March 1, 2000 (unless extended by DEP), the MWRA, in consultation with the Cities of Cambridge and Somerville, shall provide EPA and DEP with an assessment of the likely water quality benefits of each item provided by the Cities of Cambridge and Somerville.

(5) For the MWRA sewer member communities in the Alewife/Upper Mystic Basin, the MWRA shall:

i. provide copies of its Best Management Practices (BMP) Plan;

ii. provide existing GIS sewer system mapping of the municipal and relevant portions of the MWRA's wastewater system;

iii. if requested, provide technical guidance to member communities on how to perform dye testing, smoke testing, drain sampling, television inspection, and other procedures to identify or confirm the presence of illicit connections; and

iv. if requested, review/comment on the sewer member communities' stormwater management plan to identify opportunities for enhanced pollution prevention.

B. Actions to Further Assess CSO/Stormwater Pollutant Loads

Sampling Program

In the MWRA's FFP/EIR, the recommended level of CSO control in the Alewife/Upper Mystic Basin was developed based on the cost-performance comparison of CSO control alternatives and related CSO and non-CSO pollutant loads; (1) entering the Alewife/Upper Mystic Basin as upstream boundary conditions and baseline flows/loads and (2) stormwater loadings entering the CSO planning area from separate stormdrains and watercourses.

DEP is requiring that additional sampling data be obtained from these sources to more fully characterize and define flows and loads for incorporation into the sewer system and receiving water modeling runs and to validate the analyses provided in the CSO Facilities Plan.

To the extent possible, the Cities of Cambridge and Somerville shall coordinate the stormwater sampling with ongoing stormwater management activities.

(1) Receiving Water Sampling

The MWRA shall continue to actively participate in EOEA/DEP Basin activities by performing water quality monitoring in the Alewife/Upper Mystic Basin to assess the impacts of CSO discharges.

i. On or before July 1, 1999, the MWRA shall submit a report to DEP and EPA summarizing the 1998 receiving water sampling data collected in the Alewife/Upper Mystic Basin in accordance with the *Combined Work/Quality Assurance Project Plan for Water Quality Monitoring and Combined Sewer Overflow Receiving Water Monitoring in Boston Harbor and its Tributary Rivers* dated April 1998. This report shall include an interpretive discussion of sampling locations, results, and a correlation of the data with rainfall/precipitation records.

ii. Each year, on or before April 1 for the duration of this Variance, MWRA shall submit to DEP and EPA a Report on the past year's sampling program and a proposal for receiving water sampling for the current year. The Report shall include, at a minimum:

   a. A summary of the receiving water sampling data collected over the past calendar year, including sampling locations and parameters.

   b. An interpretive discussion of the results, and a correlation of the data with rainfall/precipitation records and with estimates of active CSO discharges.

   c. A proposed plan for current year sampling activities intended to measure the effect of CSO discharges in the Alewife/Upper Mystic Basin. The proposed plan shall build upon existing data in the Basin and shall include information on sampling locations and sampling parameters.

(2) <u>Stormwater Sampling</u>

MWRA and the Cities of Cambridge and Somerville shall perform representative sampling[1] semiannually for the duration of this variance at stormdrain locations throughout the Alewife/Upper Mystic Basin as further described below (the final timeframe and locations to be jointly determined by DEP and EPA, in consultation with MWRA, Somerville and Cambridge) to allow for determinations of stormwater loadings in the Alewife/Upper Mystic Basin. Samples collected shall be analyzed for fecal coliform, e. coli, enterococcus, nutrients, BOD, and TSS.

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1 In its scope of work, the MWRA and the communities shall propose automated sampling, a series of grab samples, or other methods to collect samples to adequately characterize stormwater loads at the selected locations.

i. The City of Cambridge shall conduct sampling at two locations from drainage areas discharging to Alewife Brook.

ii. The City of Somerville shall conduct sampling at 5 locations from drainage areas discharging to Alewife Brook and the Mystic River.

iii. The MWRA shall conduct sampling at 3 locations from areas which drain to the Upper Mystic Basin (as defined in the 1997 MWRA CSO FP).

Sampling locations proposed for meeting the requirements of this section shall, to the extent possible, represent runoff from the predominant land uses within each community in the Alewife/Upper Mystic Basin. Final sampling locations and timeframes for conducting the sampling work shall be subject to approval by DEP and EPA. DEP and EPA will review the sampling plan each year, along with community stormdrain information being gathered under separate concurrent initiatives, to determine if modifications to the sampling plan are required.

The MWRA, and the Cities of Cambridge and Somerville, shall submit a draft scope of work for carrying out the sampling work set forth in this section, on or before September 1, 1999. The MWRA and the communities may elect to collaborate and file a single proposal for the sampling effort. Subject to the approval of DEP, these sampling efforts may be collectively coordinated and carried out by any qualified party. In all cases, the sampling results shall be reported to DEP and EPA within one month of the sampling date.

C. Assessment of CSO Controls in the Alewife/Upper Mystic Basin

(1) Report Preparation

By January 1, 2002, the MWRA shall file a report with DEP summarizing and assessing the information obtained during the Variance process (and any other relevant documentation which is produced and available during this period) and reassess the recommended CSO control plan included in the Final Facilities Plan for the Alewife/Upper Mystic Basin. This Report must include, at a minimum:

i. information on the combined sewer systems in Cambridge and Somerville to the extent that these systems are substantially different from the systems as modeled in the Final Facilities Plan.

ii. a reassessment of the recommended CSO abatement plan in the Alewife/Upper Mystic Basin and alternatives representing higher levels of CSO control, up to and including elimination. The

reassessment must include: an analysis of the CSO, stormwater, and upstream pollutant loads of the alternatives; predictive modeling to estimate the water quality impacts of the alternatives[2]; and the costs of the alternatives.

iii a final recommended plan for CSO abatement in the Alewife/Upper Mystic Basin.

(2) Based on its analyses of CSO and stormwater impacts in the Mystic/Alewife Basin, the MWRA shall work with EPA and DEP to attempt to identify and describe one or more "triggers" appropriate to act as a basis for determining when additional CSO controls (treatment and/or storage) would yield greater benefits for their respective costs.

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2 DEP will provide guidance to MWRA on stormwater pollutant concentrations, based on the results of the stormwater sampling required under the variance and other relevant documentation compiled on stormwater quality. The impacts of reasonable stormwater management initiatives may also be considered.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

JANE SWIFT
Governor

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

PUBLIC NOTICE
FINAL DETREMINATION FOR EXTENSION TO VARIANCE FOR MWRA CSO CONTROL PLAN ALEWIFE BROOK/UPPER MYSTIC RIVER BASIN

On May 8, 2002 the Department of Environmental Protection (DEP) extended the Variance for CSO Discharges to the Alewife Brook/Upper Mystic River Basin from March 5, 2002 to September 5, 2003. This Variance extension, issued pursuant to the Massachusetts Surface Water Quality Standards at 314 CMR 4.00, allows CSO discharges from the outfalls along Alewife Brook/Upper Mystic River permitted to the Massachusetts Water Resources Authority (MWRA) and the Cities of Cambridge and Somerville, subject to specific conditions, while providing time for DEP to obtain the information necessary to determine the appropriate water quality standard and level of CSO control for the watershed.

The Department grants this Variance extension based on its findings, as supported by the technical and cost information in the 1997 MWRA CSO Facilities Plan and the subsequent April 2001 MWRA Notice of Project Change (NPC), demonstrating that implementation of more stringent CSO controls at this time would result in substantial and widespread social and economic impact as specified in 314 CMR 4.03(4).

Variance Extension Process

(1) The February 9, 2002 MEPA Environmental Monitor included a Public Notice which indicated DEP's Tentative Determination to issue an 18-month extension to the Variance. The notice stated that comments on the Tentative Determination would be accepted by DEP through February 22, 2002. Written comments were received from; Arlington Office of the Board of Selectmen, Arlington Conservation Commission, Mystic River Watershed Association, Somerville Conservation Commission, Coalition for Alewife, Roger Frymire, Aram Hollman, and Stephen Kaiser.

Attached to the Final Determination is a Response to Comments document prepared by DEP to respond to the above eight (8) comment letters.

Future DEP Administrative/Regulatory Actions Regarding Variance

(1) DEP will hold a Public Forum during the MEPA comment period related to Condition C.(1) (estimated to be mid-July 2003) for MWRA to present to interested parties the results of reports and assessments.

(2) DEP will hold a Public Hearing once the Department issues a Tentative Decision on the Water Quality Determination for the entire Alewife Brook/Upper Mystic River Basin. This will allow

another opportunity for all interested parties to provide input to EPA and DEP on the Proposed Level of CSO Control for the Basin. This Hearing will likely be held in early September 2003.

Copies of the Final Determination and Response to Comments document can be obtained by contacting Steven G. Lipman, Department of Environmental Protection, 6th floor, One Winter Street, Boston, MA 02108, by email at Steven.Lipman@state.ma.us or by telephone at (617) 292-5698.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
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ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

JANE SWIFT
Governor

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

May 8, 2002

Frederick Laskey, Executive Director
Massachusetts Water Resources Authority
100 First Avenue
Charlestown Navy Yard
Boston, MA 02129

Re: EXTENSION TO VARIANCE FOR THE MWRA CSO-CONTROL PLAN ALEWIFE BROOK/UPPER MYSTIC RIVER BASIN
Final Determination

And

Lisa Peterson, Commissioner
Cambridge Department of Public Works
147 Hampshire Street
Cambridge, MA 02139

And

Thom Donahue, Director
Somerville Department of Public Works
Franey Road
Somerville, MA 02145

Dear Messrs. Laskey and Donahue and Ms. Peterson:

On December 14, 2001, MWRA submitted to DEP a request to extend the CSO Variance in the Alewife/Upper Mystic watershed. DEP has reviewed the request, the supporting information, and has separately solicited public comments on the proposed extension to the CSO Variance. Based on this process, DEP has made a Final Determination to grant the extension request. The attached Final Determination for Extension to Variance for CSO Discharges to Alewife Brook/Upper Mystic River Basin formally extends the CSO Variance to September 5, 2003.

Background Discussion

In 1987, through a Stipulation entered in the Boston Harbor Case, MWRA accepted responsibility for developing a control plan to address CSO discharges from all CSOs hydraulically connected to the MWRA sewer system, including outfalls owned by the member communities. Under a Court-ordered schedule, MWRA developed a CSO Conceptual Control Plan in 1994, recommending more than 25 site-specific CSO projects located in Boston, Cambridge, Somerville and Chelsea. The CSO Conceptual Control Plan was later refined; and, on July 31, 1997, the MWRA filed a Final CSO Facilities Plan/Environmental Impact Report with MEPA. MEPA issued a certificate for the project on October 30, 1997.

In 1996, design and construction milestones for the 25 projects in the Final CSO Plan were added to the Federal Court Schedule, requiring implementation of the projects. MWRA is directly responsible for implementation of many of the projects and has negotiated agreements with each of the four CSO communities for implementation of certain projects affecting the community systems. The Facilities Plan evaluated and selected abatement alternatives for each CSO and was conducted in accordance with both EPA's National CSO Control Policy and DEP's August 11, 1997 CSO Guidance for Abatement of Pollution from CSOs.

For those CSOs which MWRA did not believe could be eliminated, the plan included information to support a Use Attainability Analysis (UAA), which is an evaluation conducted by the state which supports removal of a National Goal Use based on technical and financial criteria associated with attaining that use. DEP submitted its Final Administrative Determinations, including a UAA, to EPA for approval on December 31, 1997. On February 27, 1998, EPA approved the state's changes to water quality standards which included removal of CSO-impacted designations for the Neponset River, North Dorchester Bay, South Dorchester Bay, and Constitution Beach; a SB_{CSO} designation for Boston Inner Harbor; a B_{CSO} designation for the Muddy River; and a tentative determination for the issuance of Variances for the Lower Charles River and the Alewife Brook/Upper Mystic River Basins.

A Variance for CSO discharges to the Alewife Brook/Upper Mystic River Basin was issued by DEP on March 5, 1999. The Variance is a short-term modification of the Water Quality Standards allowing CSO discharges from the outfalls along the Alewife Brook/Upper Mystic River permitted to the Massachusetts Water Resource Authority (MWRA) and the Cities of Cambridge and Somerville, subject to specific conditions, while providing time for DEP to obtain the information necessary to determine the appropriate water quality standard and level of CSO control for the Basin. The Variance required the implementation of the CSO control actions included in the MWRA Final CSO Facilities Plan/Environmental Impact Report and other actions necessary to credibly assess pollutant loads in the Basin and minimize the impact of CSO discharges.

The March 5, 1999 Alewife Brook/Upper Mystic River Basin Variance included the following specific conditions of the MWRA and the Cities of Cambridge and Somerville:

- Implement the $12.1 million CSO control program in the 1997 FFP/EIR in the Alewife Brook/Upper Mystic River Basin (these controls were determined to be cost-effective).
- Monitor and estimate CSO activations and volumes.

- Prepare and submit a Report on the CSO abatement benefit of infiltration and inflow (I/I) reduction programs.
- Initiate and report on water quality sampling programs in the Alewife Brook/Upper River Mystic Basin, including in-stream and stormwater sampling.
- By January 1, 2002, submit a report summarizing information gathered during the Variance process and reassessing the costs and benefits of additional CSO controls in the Alewife Brook/Upper Mystic River Basin, up to and including elimination of CSOs.

The January 1, 2002 Reassessment Report was intended to provide the basis for a final determination on the level of CSO controls to be required.

In the course of implementing the 1997 CSO control program for the Alewife Brook, the City of Cambridge and MWRA determined during the design phase that the nature of the combined sewer system in Cambridge was significantly different from that documented in the 1997 FEIR. Not only were there significantly more cross-connections, but a previously unknown CSO outfall was also discovered. The MWRA subsequently determined that the CSO activations and volumes in this basin greatly exceeded that estimated in the 1997 FEIR, and that the 1997 recommended plan no longer represented an effective approach to mitigate CSO discharges.

In response to this, MWRA and Cambridge completed a re-evaluation of the original CSO control plan for Alewife Brook and on April 30, 2001 filed a Notice of Project Change (NPC) with MEPA. While the level of CSO control for the revised recommended plan is comparable to the original 1997 plan and remains essentially one of targeted sewer separation, certain elements of the original plan, including areas slated for separation, have been substantially modified, resulting in a change in expected impacts and mitigation measures. The estimate of annual CSO volume and activation frequency increased significantly and the estimated costs of the project increased over six-fold, from $12 million to approximately $74 million. Notably, sewer separation associated with the CAM004 outfall will require construction of a new stormwater outfall to convey flows to a new wetland detention basin proposed within the MDC Alewife Reservation. This component was not in the original recommended plan and introduces an additional aspect to the scope of work that is substantially different from the typical pipe installation work in streets associated with the sewer separation activities.

Implementation of the recommended plan included in the NPC will result in an 84 percent reduction in annual CSO volume discharged in a typical year, and improved stormwater quality resulting in a reduction in stormwater pollutant loads to Alewife Brook.

In its June 15, 2001 Certification on the NPC, the Secretary of the Executive Office of Environmental Affairs required that MWRA and Cambridge prepare and file with MEPA a comprehensive Response to Comments document to address those comments received on the NPC. MWRA and Cambridge have been working on this document. However, due to the need for additional water quality work and hydraulic modeling and analysis to fully address complex permitting aspects, the Response to Comments document will not be filed until September 2002.

On December 14, 2001, MWRA submitted to DEP a request to extend the CSO Variance in the Alewife Brook/Upper Mystic River Basin. The request cited the lack of sufficient stormwater data, the changed conditions which prevented implementation of the 1997 CSO Plan, and the need for additional time to develop the information necessary to support the Final CSO Reassessment Plan.

Variance Extension Process

DEP reviewed the Variance extension request and the supporting information and proceeded to solicit public comments on the proposal to extend the CSO Variance. The February 9, 2002 MEPA Environmental Monitor included a Public Notice which indicated DEP's Tentative Determination to issue an 18-month extension to the Variance, and provided for public comment period through February 22, 2002. During this public comment period, DEP also held a public meeting on February 11, 2002 at Arlington Town Hall to discuss the proposed CSO Variance and general CSO regulatory issues related to the MWRA CSO Plan.

Written comments were received from; Arlington Office of the Board of Selectmen, Arlington Conservation Commission, Mystic River Watershed Association, Somerville Conservation Commission, Coalition for Alewife, Mr. Roger Frymire, Mr. Aram Hollman, and Mr. Stephen Kaiser.

Attached to the Final Determination is a Response to Comments document prepared by DEP to respond to the comments received. The Response to Comments document was set-up to respond to basic categories of comments and not to each individual comment.

DEP has considered the MWRA request for extension, the supporting information, and the comments from the public in making this determination to extend the CSO Variance. The attached Final Determination to Extend the Variance includes a description of the Variance conditions, and highlights those conditions which have been revised based on information developed during both the CSO planning process and the public participation process.

The information being gathered over the course of the Variance is intended to provide the basis for a determination on the final level of CSO control and associated water quality standard for the Alewife Brook/Upper Mystic River. During the Variance period, the MWRA, and the Cities of Cambridge and Somerville are required to comply with all of the conditions established by this Variance Extension.

Future DEP Administrative/Regulatory Actions Regarding Variance

(1) DEP will hold a Public Forum during the MEPA comment period related to Condition C.(1) (estimated to be mid-July 2003) for MWRA to present to interested parties the results of reports and assessments.

(2) DEP will hold a Public Hearing once the Department issues a Tentative Decision on the Water Quality Determination for the entire Alewife Brook/Upper Mystic River Basin. This will allow another opportunity for all interested parties to provide input to EPA and DEP on the Proposed Level of CSO Control for the Basin. This Hearing will likely be held in early September 2003.

If you have any questions regarding this correspondence or the appended Final Determination, feel free to contact me at (617) 292-5698 or Kevin Brander at (978) 661-7770.

Very truly yours,

Steven G. Lipman, P.E.
Special Projects Coordinator

CC: Michael Hornbrook, David Kubiak, Stephanie Moura and Christopher John (MWRA)
Owen O'Riordan (Cambridge DPW)
Mike Wagner, Eric Hall and Brian Pitt (EPA)
Mark Smith (EOEA)
Dick Foster (MEPA)
Cynthia Giles, Glenn Haas, Eric Worrall, William Gaughan, Madelyn Morris and Kevin Brander (DEP)

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FINAL DETERMINATION FOR EXTENSION TO VARIANCE FOR CSO DISCHARGES TO ALEWIFE BROOK/UPPER MYSTIC RIVER BASIN

The Department of Environmental Protection (DEP) hereby extends the Variance for CSO Discharges to the Alewife Brook/Upper Mystic River Basin from March 5, 2002 to September 5, 2003. This Variance extension, issued pursuant to the Massachusetts Surface Water Quality Standards at 314 CMR 4.00, allows CSO discharges from the outfalls along Alewife Brook/Upper Mystic River permitted to the Massachusetts Water Resources Authority (MWRA) and the Cities of Cambridge and Somerville, subject to specific conditions which follow, while providing time for DEP to obtain the information necessary to determine the appropriate water quality standard and level of CSO control for the watershed.

The Department grants this Variance extension based on its findings, as supported by the technical and cost information in the 1997 MWRA CSO Facilities Plan and the subsequent April 2001 MWRA Notice of Project Change (NPC), demonstrating that implementation of more stringent CSO controls at this time would result in substantial and widespread social and economic impact as specified in 314 CMR 4.03(4).

MWRA and the Cities of Cambridge and Somerville shall implement the revised recommended plan included in the April 2001 Notice of Project Change in place of the CSO abatement plan for the Alewife Brook/Upper Mystic Basin included in the approved 1997 MWRA CSO Facilities Plan. The implementation schedule will be as set forth in modifications to the Federal Court Order.

The Variance Extension becomes effective upon issuance and will be incorporated into the NPDES/MA permits for the MWRA and the Cities of Cambridge and Somerville, through modification or reissuance during the term of the Variance, with an additional opportunity for public comment. Failure by the MWRA and/or the Cities of Cambridge or Somerville to comply with the conditions of the Variance prior to permit modification or reissuance will constitute a violation of the existing permit, as well as the Massachusetts Surface Water Quality Standards.

VARIANCE CONDITIONS

All requirements and conditions of the March 5, 1999 Variance for CSO Discharges to the Alewife/Upper Mystic Basin remain in effect through the term of this Variance extension, subject to the exceptions and modifications which follow:

A. Actions to Minimize CSO/Sanitary Disharges

The following requirement replaces Section A.(1) in its entirety:

> MWRA and the Cities of Cambridge and Somerville shall continue to implement the Nine Minimum Controls (NMC), monitor CSO activations and volumes, and implement the elements of the revised recommended plan included in the April 30, 2001 Notice of Project Change.
>
> The NMC Reports were filed in 1997 and were largely based on EPA Guidance for Nine Minimum Controls (May 1995). Some of the information in these reports is somewhat dated and needs to be updated. Of particular concern is the nature and extent of the public notification requirements relative to CSO discharges and potential impacts
>
> The public notification currently performed has included: posting of CSO outfalls; submitting NPDES reports and discharge monitoring reports; coordinating with Massachusetts Division of Marine Fisheries on impacts to shellfish resources; publishing and including on their website water quality information and annual reports from sampling programs; and publishing a CSO newsletter during the CSO planning process. Enhancements to the public notification practices are warranted for those most directly affected by CSO discharges.
>
> By June 14, 2002, MWRA, in conjunction with the cities of Cambridge and Somerville, shall submit to DEP a workplan to provide improved public notification on the CSO discharges and potential impacts, and shall fully implement it once approved by DEP.

The following requirement is added to Section A.(2):

> iv. By June 28, 2002 MWRA, in cooperation with the Cities of Cambridge and Somerville, shall provide to EPA and DEP a draft of an updated and expanded workplan to estimate CSO overflows for all remaining overflows covered by this Variance.
>
> The final workplan shall be implemented by MWRA, Cambridge and Somerville in accordance with the schedule included with DEP's approval of the final workplan.

The following requirement is added to Section A.(3):

> MWRA shall continue to work with EPA, DEP and its member communities regarding the recommendations of the MWRA Regional Infiltration/Inflow Task Force to minimize

the impacts of I/I flows, and, where possible, identify opportunities for I/I removal in the upstream separate sewer systems which may further mitigate CSO discharges.

B. Actions to Further Assess CSO/Stormwater Pollutant Loads

(2) Stormwater Sampling is modified as follows:

The approved locations for stormwater monitoring were based on a number of factors including volume of the discharge and types of land use. The limited sampling has shown that there appear to be sanitary influences at a number of these outfalls. DEP will work with MWRA, Cambridge and Somerville and others to determine if substitute stormwater outfalls are more appropriate for characterization of stormwater loads within the watershed.

MWRA and the Cities of Cambridge and Somerville shall continue to conduct semiannual stormwater sampling as per section B.(2). of the Variance, utilizing the locations and the procedures established in a revised sampling program to be developed among the parties and approved by DEP. MWRA and the cities of Cambridge and Somerville shall submit a workplan identifying the stormwater sampling locations by July 1, 2002. The revised sampling locations shall be included in the Fall 2002 sampling run and for each subsequent sampling event thereafter during the course of this Variance.

A new requirement is added to this section:

(3) CSO Sampling

The sampling to characterize CSO pollutant loads in support of the 1997 CSO Facilities Plan included limited sampling of CSOs in the Alewife Brook watershed. Although many CSO samples were collected for the overall planning effort, no samples were collected from the facilities which presently discharge CSO to Alewife Brook. MWRA is therefore required to conduct representative sampling at two CSO locations during two separate CSO activation events to provide additional data to support the CSO loading analysis to be included in the Final CSO Reassessment. MWRA shall provide a workplan to DEP for conducting this sampling by July 1, 2002.

C. Assessment of CSO Controls in the Alewife/Upper Mystic Basin

The submission date for Variance Condition C.(1) is revised from January 1, 2002 to July 1, 2003. A scope of work for the effort shall be submitted by MWRA to DEP and EPA by September 1, 2002 for review and approval.

Items (1) i through iv are replaced by the following:

i. a description of the combined sewer systems in Cambridge and Somerville, and other associated interceptors and sewer system facilities.

ii. a reassessment of the recommended CSO abatement plan in the Alewife/Upper Mystic Basin and alternatives representing higher levels of CSO control, up to and including elimination. The reassessment must include: an analysis of the CSO, stormwater, and upstream pollutant loads of the alternatives; predictive modeling to estimate the water quality benefits of the CSO abatement alternatives; measures to be taken to minimize CSOs and mitigate impacts of any CSO discharges which will not be eliminated; and the costs of the alternatives.

iii. a final recommended plan for CSO abatement in the Alewife/Upper Mystic Basin, which shall comply with state and federal CSO policies.

iv. a description of the financial impact of the recommended CSO abatement plan, developed pursuant to EPA Guidance.

Future DEP Administrative/Regulatory Actions Regarding Variance

(1) DEP will hold a Public Forum during the MEPA comment period related to Condition C.(1) (estimated to be mid-July 2003) for MWRA to present to interested parties the results of reports and assessments.

(2) DEP will hold a Public Hearing once the Department issues a Tentative Decision on the Water Quality Determination for the entire Alewife Brook/Upper Mystic River Basin. This will allow another opportunity for all interested parties to provide input to EPA and DEP on the Proposed Level of CSO Control for the Basin. This Hearing will likely be held in early September 2003.

Please contact Steven G. Lipman, Department of Environmental Protection, 6th floor, One Winter Street, Boston, MA 02108 or by telephone at (617) 292-5698 if you have questions regarding this determination.

5/8/02
Date

Glenn S. Haas
Director
Division of Watershed Management

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Department of Environmental Protection
Responses to Comments
Received on Proposed Extension to Alewife/Upper Mystic CSO Variance

May 8, 2002

1. *How are MWRA and the Cities of Somerville and Cambridge implementing the Nine Minimum Controls to mitigate existing CSO discharges?*

   MWRA and the Cities of Cambridge and Somerville have all submitted Reports documenting efforts to comply with the Nine Minimum Controls. These Reports are on file with the permittees, with DEP, and with EPA. These Reports were filed in compliance with the EPA CSO policy by January 1997 and were largely based on EPA Guidance for Nine Minimum Controls (May 1995). Some of the information in these reports is somewhat dated and needs updating. The NPDES permit reissuance will require the permittees to update these reports to note improved conditions and practices.

2. *The NMC related to public notice of CSO discharges and their impacts should be expanded significantly, to inform abutters and users of Alewife Brook so that information on activations is being provided in real time.*

   The public notification done by MWRA and the communities as part of their NMC programs has included: posting of CSO outfalls; submitting NPDES reports and discharge monitoring reports; coordinating with DMF on impacts to shellfish resources; publishing and including on their website water quality information and annual reports from sampling programs; and publishing a CSO newsletter during the CSO planning process. Numerous commenters have suggested more of a real-time notification for impacted parties. DEP will work with the permittees and EPA to explore methods of improved and timely notification. A workplan will be required under the CSO Variance to provide improved public notification on the CSO discharges and potential impacts and will be available for review by the EOEA Watershed Team.

3. *What is the status of the enforcement related to the 308 letters which require identification and removal of illegal connections in the Alewife/Mystic River Watershed? Progress has been slow.*

Water quality information in the Alewife Brook and Mystic River Basins has indicated that water quality standards are violated even during dry weather periods, which suggests the presence of illegal wastewater connections to separate stormwater drainage systems in the watershed. EPA, at DEP's request, issued Clean Water Act Section 308 information requests ("308" letters) to Medford, Somerville, Belmont, Arlington, Cambridge, Winchester, and MDC. EPA required each community to survey their stormwater outfalls during dry weather and sample those outfalls found to have flow. Based on the results of this effort, DEP issued Notices of Noncompliance (NONs) to each community requiring the communities to initiate programs to identify and remove illegal wastewater connections to their storm drain systems where observations and sampling were indicative of wastewater pollution. While a number of the communities have made significant progress in this regard, much work still remains.

DEP has recently met with staff from the Mystic River Watershed Association to go over the water quality information which has been gathered in the watershed which may be helpful in identifying further sources of pollution. DEP will use this information and other water quality data to continue to refine these endeavors and target the worst suspected pollutant sources. DEP will update the EOEA Watershed Team at the quarterly meetings on the progress of the work. Illegal connection removal plans and water quality information will be kept on file at the DEP Northeast Regional Office for public review.

4. *DEP should create a technical advisory group, including the Mystic River Watershed Association, MWRA, City of Cambridge, and DEP to review the work moving forward under the Variance and to support pollution abatement programs.*

DEP will utilize the existing EOEA Mystic River Watershed Team for stakeholder review of documents related to the CSO Variance. The EOEA team includes members from the Mystic River Watershed Association and other watershed advocacy groups as well as other state agencies and interested parties. DEP will provide information on the required CSO Variance submittals at watershed team meetings and by direct mailing, as appropriate, and will consider comments received from team members in moving forward with CSO abatement work.

The most critical submittal, the CSO Reassessment Report, will be subject to public environmental review through the MEPA office. Numerous public meetings will also be conducted by MWRA during the development of the Report to update interested parties on the status of the work and to invite public comments and questions.

5. *How will the Phase II NPDES Stormwater permitting program factor in to decisions on CSOs and the Variance?*

All of the communities in the Alewife Brook and Mystic watersheds will be subject to the Phase II NPDES Stormwater Permit Program. Communities are required to submit a Permit Application by March 10, 2003. Permits will require that communities implement six Best Management Practices (BMPs) and document stormwater management efforts as set forth in the EPA regulation. EPA is expected to have an outreach program in 2002 to provide further detail on the level of stormwater controls which will be necessary to meet performance standards associated with the six BMPs. DEP recognizes stormwater to be a separate (from CSOs) but critical pollutant source in the Mystic/Alewife Basin. Information on existing stormwater and CSO pollutant loads being gathered will help all interested parties to understand the relative impacts of these discharges and the corresponding benefits of CSO and stormwater pollution abatement efforts. However, the level of CSO control provided must meet the regulatory standards, and reflect the maximum pollution reduction benefits reasonably attainable, up to and including elimination where elimination is affordable and feasible.

6. *When will NPDES permits for MWRA and the Cities of Cambridge and Somerville be reissued?*

NPDES permits will be reissued in 2002, with a target date of July 1. A Draft of each permit will be public noticed with an opportunity for public comments. The NPDES permits are issued jointly from EPA and DEP. These permits require that dischargers comply with the water quality standard. Where a CSO Variance has been issued, the Variance and any conditions imposed represent the standard during the timeframe of the Variance.

7. *Will programs to target infiltration/inflow removal be implemented as part of a CSO abatement strategy?*

MWRA completed a Report pursuant to the CSO Variance which considered the benefits of aggressive, system-wide infiltration/inflow (I/I) removal programs. Their conclusion was that there would be negligible benefit in CSO reduction from aggressive I/I programs. DEP has not concurred with this conclusion to date. The extent of achievable long-term I/I reduction is the subject of national debate; EPA is preparing to issue regulations which will have a substantial impact on operation and management of sewer systems. DEP recognizes the general environmental and sewer system benefits from I/I reduction work and the specific benefits of targeted I/I remediation actions.

In March 2001 the MWRA Regional I/I Task Force, comprised of MWRA, its 43 member communities, four Watershed Associations (including the MyRWA), DEP, EPA, and other interested parties issued its Final Report titled: "A Guidance Document For MWRA Member Sewer Communities and Regional Stakeholders" which includes a series of Goals and Implementation Strategies providing for a comprehensive regional approach to address I/I, Sanitary Sewer Overflows (SSO)/Backups, and Operation, Maintenance &

Rehabilitation (OM&R). MWRA subsequently filed on June 30, 2001 with EPA and DEP its NPDES Permit-required plans for addressing these same issues, using the Task Force Report as a guide. DEP has provided MWRA with detailed comments on these filings and EPA is expected to provide comments later this month. MWRA will respond in writing to DEP/EPA comments and then a process of discussions/negotiations will take place, the intent being to agree upon a final plan which will become an enforceable element of the NPDES Permit.

DEP is pressing forward for formal development/implementation of a comprehensive regional SSO Strategy, I/I control and OM&R approach. DEP strongly believes that a regional I/I Control Program (specifically including redirection/removal of private sources of inflow) in conjunction with a comprehensive OM&R Program must be expeditiously implemented by MWRA and its 43 member communities. As part of a condition of an Administrative Consent Order between DEP and MWRA to construct the Braintree-Weymouth Relief Facilities and as required in the MWRA NPDES Permit, staff from DEP and MWRA have recently initiated negotiations to develop an I/I Interagency Agreement (would expand upon a prior DEP/MWRA 1991 I/I MOU).

In accordance with a recommendation of the Task Force Report, DEP is developing comprehensive Statewide OM&R Guidelines. In order to incorporate the best information into these guidelines it was decided to utilize the expertise of the New England Interstate Water Pollution Control Commission (NEIWPCC). This activity is anticipated to extend through 2002. As part of the outreach activities for this activity, DEP will be organizing a Technical Advisory Committee (TAC) which will include many of the parties that served on the I/I Task Force.

These collective strategies will also serve to reduce system surcharging which contributes to CSO discharges and therefore should have overall benefits to the CSO abatement program. The sewer separation work included in the MWRA CSO abatement plan in Cambridge will also serve to remove a significant volume of public (stormwater) inflow into the sewer system as well.

8. *Flooding is a major issue in the Alewife Brook subwatershed. How will further CSO planning and the recommended CSO control plan address flooding issues?*

DEP recognizes that flooding is a critical issue in the Mystic/Alewife Watershed. The CSO abatement work (i.e. sewer separation work) being designed in the City of Cambridge must adequately mitigate flow and pollutant loads from new stormwater flows generated as part of that project. The Wetlands Protection Act and associated regulations require that there be no increase in the horizontal or vertical extent of flooding which will result from this project, unless a Variance to such regulations is supported and issued. The City of Cambridge is currently developing an advanced hydraulic model to better assess potential impacts from the project to demonstrate that these regulatory standards will be met.

DEP also supports efforts to alleviate flooding problems in the Alewife/Mystic watershed and staff recently attended the Flood Alert public meeting in Belmont, where representatives of MyRWA and three communities in the Alewife Brook watershed discussed flood control and pollution abatement programs. DEP is committed to work (within the scope of our regulatory authority) with the communities, the watershed team, and relevant state and federal agencies in supporting these efforts. In that regard, DEP is continuing to participate in workgroups initiated by State Senator Shannon and State Representative Paulson.

9. *Flood storage for the Cambridge sewer separation project will only serve as a temporary fix since continued development will result in increases to runoff in the Basin.*

Historical development patterns have undoubtedly exacerbated flood conditions in the Alewife and Mystic River watersheds. DEP's Stormwater Policy and associated stormwater performance standards provide a regulatory framework for managing impacts from most new development projects (some smaller development projects are exempt). Redevelopment projects must also meet these criteria to the maximum extent practicable. The criteria are enforced by local conservation commissions and the DEP Wetlands Division staff, and include:

- No new stormwater conveyances may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth;
- Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates;
- Loss of annual recharge should be minimized through the use of infiltration measures to the maximum extent practicable;
- Stormwater management systems must be designed to remove 80% of the average annual load of total suspended solids (TSS);
- Stormwater discharges from areas with higher potential pollutant loads require the use of specific stormwater BMPs;
- Stormwater discharges to critical areas must utilize certain stormwater management BMPs approved for use in these applications;
- Redevelopment of previously developed sites must meet the standards to the maximum extent practicable, and, at a minimum, shall be designed to improve existing conditions;
- Erosion and sediment controls must be implemented to prevent impacts during construction or land disturbance activities;
- All stormwater management systems must have an operation and maintenance plan to ensure that systems function properly.

DEP's Policy does not respond to the effects of past planning and development practices in each community and the existing flood control challenges which have resulted. Flood management and hydrology studies now underway in the watershed should help the communities and agencies understand the best strategies to address the existing flooding problems and identify projects to mitigate flood impacts.

10. *The state should review runoff reduction strategies not only related to the CSO abatement efforts but throughout the watershed, since flooding concerns and associated public health impacts are severe.*

    DEP will continue enforcement of the Stormwater Policy, the "308" initiative to eliminate illegal connections, and will review each community's Phase II stormwater management plan when available. DEP will also participate in group efforts to develop strategies and promote projects to relieve flooding in these watersheds. DEP concurs that flooding and pollution abatement are watershed issues and need to be considered from this perspective; only through participation and commitments from all stakeholders will these problems be successfully managed.

11. *The Variance extension should include a defined scope of work which MWRA will include in the Final CSO Reassessment Report.*

    DEP will require MWRA to submit a draft scope of work for the CSO Reassessment Report. The draft scope will be public information and will be available for review at the DEP office. Members of the EOEA watershed team and other interested parties will have the opportunity for review and comment.

12. *A better description of the operation of MWR 003 is warranted. Quarterly reports on the frequency, duration, and volume of overflow should be made available and metering should be installed.*

    DEP agrees that MWRA should provide additional detail on the operation of MWR 003 and report on the frequency, duration, and volume of CSO discharge at this location. DEP will be requiring a flow estimation workplan for all remaining Alewife/Mystic CSO outfalls that is expected to include a combination of metering and modeling to estimate CSO flows. Again, this plan will be available for review at the DEP office and the watershed team will have the opportunity for review and comment.

13. *MWRA should be required to install and place meters in each connection to the Alewife Brook sewers to adequately characterize flows.*

    MWRA utilized 16 flow meters installed throughout the Mystic/Alewife Watershed to support their enhanced modeling effort, and included flow meters to characterize boundary conditions, runoff, and wastewater in the planning area. The locations of the meters and a discussion of the data are included in the April 2001 NPC document. This level of metering is consistent with that normally associated with CSO planning to support the sewer system modeling and produce reasonable calibration results. If there are specific areas in the system where concerns exist about the model, stakeholders can contribute to this information during the planning process which will lead up to the submittal of the CSO Reassessment Report.

14. *The stormdrains selected for sampling to characterize stormwater pollutant loads were among those with suspected illegal connections. DEP should require sampling of more representative, "cleaner", stormwater, such as at Arlington's Broadway/Mass Ave. drains and road drains along Route 2.*

The stormdrains selected for stormwater monitoring were based on a number of factors, including volume of the discharge and types of land use. Some, but not all, of these locations were identified in the 308 programs. In these cases, the communities have taken steps to mitigate or eliminate wastewater sources. However, the limited stormwater sampling has shown that there appear to be sanitary influences at a number of these outfalls. As per the suggestion, DEP will work with MWRA, the communities, EPA, and Mystic River Watershed Association to determine the most representative outfalls of stormwater for characterization of stormwater loads within the watershed and to incorporate into the CSO Variance in subsequent sampling runs.

As the intent of this sampling work is to gather data to help characterize stormwater pollutant loads in the Alewife/Mystic watershed, DEP will consider wet weather data from other sources, such as the Mystic River Watershed Association, in determining an appropriate range for estimating pollutant concentrations in stormwater in the watershed.

15. *The characterization of pollutant concentration from combined sewage should be done based on sampling within the Alewife/Mystic watershed.*

MWRA CSO sampling, done in 1994, included three sampling locations in Somerville – SOM 003, SOM 009, and Somerville Marginal Influent. Outfall SOM 003 discharged (it has since been eliminated) to Alewife Brook. A total of 221 samples of untreated CSO were used to develop the average pollutant loads, which is a significant number of samples and provides a reasonable basis for estimating CSO pollutant loads. However, as there were no samples collected from the facilities which presently discharge CSO to Alewife Brook, DEP will require two CSO locations to be sampled as part of the semiannual stormwater sampling program.

16. *Quarterly reports on the frequency of sanitary sewer overflows (SSOs) should also be available to the public.*

DEP staff have developed updated/expanded SSO and Backup Notification Forms to be used as part of the State's e-gov initiative, whereby DEP will be developing an electronic SSO/Backup database. Information from the database will be placed on GIS maps and made available. This will allow MWRA, the municipalities and other interested parties to identify problem areas in the regional sewer system. This system is not expected to become functional until at least mid-2003. DEP is reviewing internally whether it would be possible to expedite a portion of this effort. Until such time, communities are still required to report SSO events to the DEP and these records will be kept on file, and available for public review.

17. *Final regulatory determinations on CSOs should consider not only MWRA sampling, but also sampling undertaken by the Mystic River Watershed Association pursuant to its approved Quality Assurance Project Plan (QAPP).*

    DEP will use MyRWA sampling results where such results have been gathered pursuant to an approved Quality Assurance Project Plan (QAPP), and will generally consider all credible water quality data in refining the scope and timeframe for CSO and stormwater pollution abatement efforts. DEP recognizes that these sampling programs, which also includes significant historical water quality data gathered by MWRA, are important to prioritizing work in the watershed.

18. *DEP should make data gathered under the Variance and related information available via the Internet.*

    MWRA provides much water quality data on their website. DEP does not currently have the resources to develop and manage putting the data on the website. DEP will make available to the public data and information gathered pursuant to the Variance requirements. DEP will also participate in Watershed Team Meetings and disseminate information in this forum as well.

19. *DEP needs to consider the public health impacts of the CSO discharges, which result in untreated sewage reaching residential homes.*

    DEP's CSO Policy requires permittees to eliminate CSO discharges wherever feasible. Where CSOs will not be eliminated, CSO discharges shall be minimized and their impacts must be mitigated to the maximum extent feasible. Accordingly, MWRA must evaluate alternatives to eliminate CSOs in their CSO Reassessment Report, and where CSOs are not eliminated, consider measures to mitigate the impacts of any remaining discharges.

    Officials at the Department of Public Health (DPH) have contacted DEP and discussed the proposed CSO abatement projects and the overall CSO planning effort. DEP will consider DPH comments on the CSO Reassessment Plan prior to making final determinations on CSO controls.

20. *DEP should address the substantial delays in implementing CSO controls in Alewife Brook, which were required to move forward under an aggressive schedule established in the Court Order.*

    DEP acknowledges that there has been substantial delay in implementation of sewer separation projects, largely based on the incomplete characterization of the combined sewer system and on the many complex issues related to the Cambridge sewer separation projects. MWRA is presently out of compliance with a federal court schedule requiring this CSO abatement work. The Court Parties have been advised on the status of the work and ultimately the federal judge, with input from the Court Parties, will determine the new schedule and any remedies to be imposed.

As has been our practice throughout the CSO abatement program, DEP will work with EPA and the Court Parties to put in place an enforcement schedule which expeditiously addresses CSO discharges and their impacts, within the technical constraints identified for each abatement project.

21. *The Variance extension should include the requirement for developing a Total Maximum Daily Load (TMDL) analysis.*

The requirement for development of TMDLs rests with the state water quality standards authority, in this case, DEP. TMDLs are required wherever receiving waters have been determined to be impaired and formally listed on the state CWA section 303D listing. DEP is moving forward with TMDL development. The Alewife Brook and Mystic River watersheds are among the 1500 segments for which TMDLs must be produced. The level of water quality information being gathered by MWRA in the CSO planning effort and pursuant to the CSO Variance is commensurate with the level of information often used to support TMDL analyses. This information should be helpful in completing a TMDL for the Alewife and Mystic River segments, similar to TMDLs completed in other watersheds.

22. *The CSO Variance should not be extended and the B classification for the Alewife/Mystic reinstated.*

CSO elimination and attainment of the Class B standard remain the goal for Alewife Brook and the Mystic River. However, key information on the feasibility of higher levels of CSO control will not be known until completion and review of the CSO Reassessment Plan, which will also rely on the implementability of the Cambridge sewer separation work. The use of a CSO Variance in this case comports with the July 2001 EPA Guidance on Coordinating CSO Long-Term Planning with Water Quality Standard Reviews.

23. *DEP should carefully scrutinize any pollution trading strategy and should ensure that all sewage discharges to Alewife Brook are eliminated.*

Any pollution trading strategies must be conclusively demonstrated to result in water quality benefits greater than those possible through CSO mitigation alone. The prevailing regulatory requirements for CSO abatement still must be satisfied.

24. *More funding resources need to be committed to stormwater management and I/I reduction.*

DEP has a number of grant programs which fund stormwater management and non-point source pollution abatement. These include the CWA section 319, 104B, and 604B grant programs. The State Revolving Fund (SRF) program also funds water pollution abatement projects on a larger scale, including I/I abatement projects. All of these programs are competitive programs where projects are rated statewide to determine

priorities. There are many other agencies which offer grants as well and DEP can provide to stakeholders a matrix recently developed which describes a great many of these programs. One very much utilized and effective program has been the MWRA's grant/loan program to member communities to fund projects to identify and eliminate I/I in community sewer systems.

25. *The siting of a detention basin on MDC parkland is an inappropriate use of parkland and should not be included as part of the sewer separation project.*

The recommendation to site the detention basin in the Alewife Reservation was made only after a detailed assessment of the alternatives for stormwater storage/treatment related to the Cambridge sewer separation project. The many other alternatives reviewed were either substantially more costly, had more environmental impacts, or had construction periods of over ten years. MWRA and the City of Cambridge have received many comments on the proposed detention basin in the MEPA process and are now putting together the technical information to address these comments. MWRA and Cambridge have included a biologist on the consultant team and will be including provisions to minimize construction and environmental impacts. MDC has met with MWRA and Cambridge and will continue to scrutinize the ecological value of the project and discuss how the facility can be integrated into the master plan. In addition, Article 97 legislation will be needed to allow this use, therefore the public through their representatives will have additional opportunity to have input.

MWRA and Cambridge are now in the process of developing responses to the great many issues that were raised in the public environmental review process. Comments on flood management, pollution abatement, and ecological impacts will all be addressed in their response document, as required by the MEPA certification for this project. Many of these responses relate directly to the proposed detention basin, its location and design.

26. *DEP should request that MEMA evaluate the effectiveness of the earthen berm designed to hold back flood waters up to the 25 storm event.*

The Department of Environmental Management (DEM) and the Federal Emergency Management Agency (FEMA) are involved in the regulatory review of the Cambridge sewer separation project with regard to flooding impacts and mitigation. They will, therefore, review the design of the project (and the flow model) and the projected impacts.

27. *DEP should request that the Army Corps of Engineers remap the Alewife floodplain.*

FEMA is now in the process of updating the Flood Insurance Rate Maps (FIRM). These new maps are expected to take at least two years to finalize.

28. *The costs of a refined, continued sampling program are not excessive and DEP should require MWRA to gather water quality data.*

DEP agrees that MWRA will need to continue to conduct receiving water and stormwater sampling to support the final CSO Reassessment Plan. The scope of this effort is expected to be similar to the level of effort associated with the previous sampling effort, but refined to gather the most useful data.

29. *MWRA should be required to publish several notices in the paper over the Variance extension period to apprise the community of the frequency of CSOs and associated health hazards.*

MWRA will be asked to renew its quarterly newsletter to stakeholders in the watershed. This will provide updates on the status of the CSO abatement efforts, notice on CSO discharges and their impacts, as well as to note important meeting dates.

30. *The public comment period on the final CSO Reassessment Report should be extended to 60 days to allow for a complete and detailed review.*

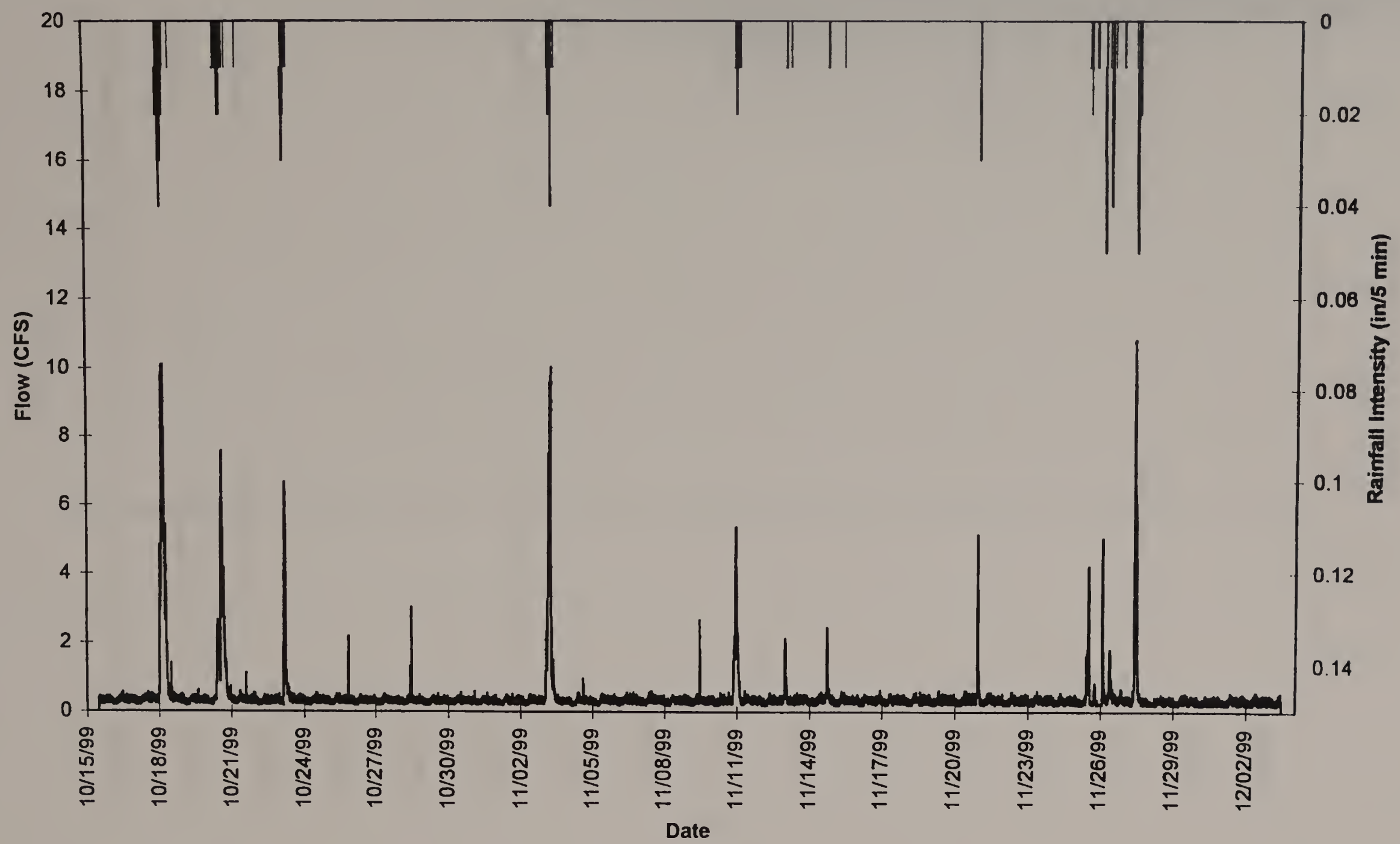
DEP agrees that a 60 day review period would be most reasonable to review the complex technical and financial information to be included in the CSO Reassessment Plan.

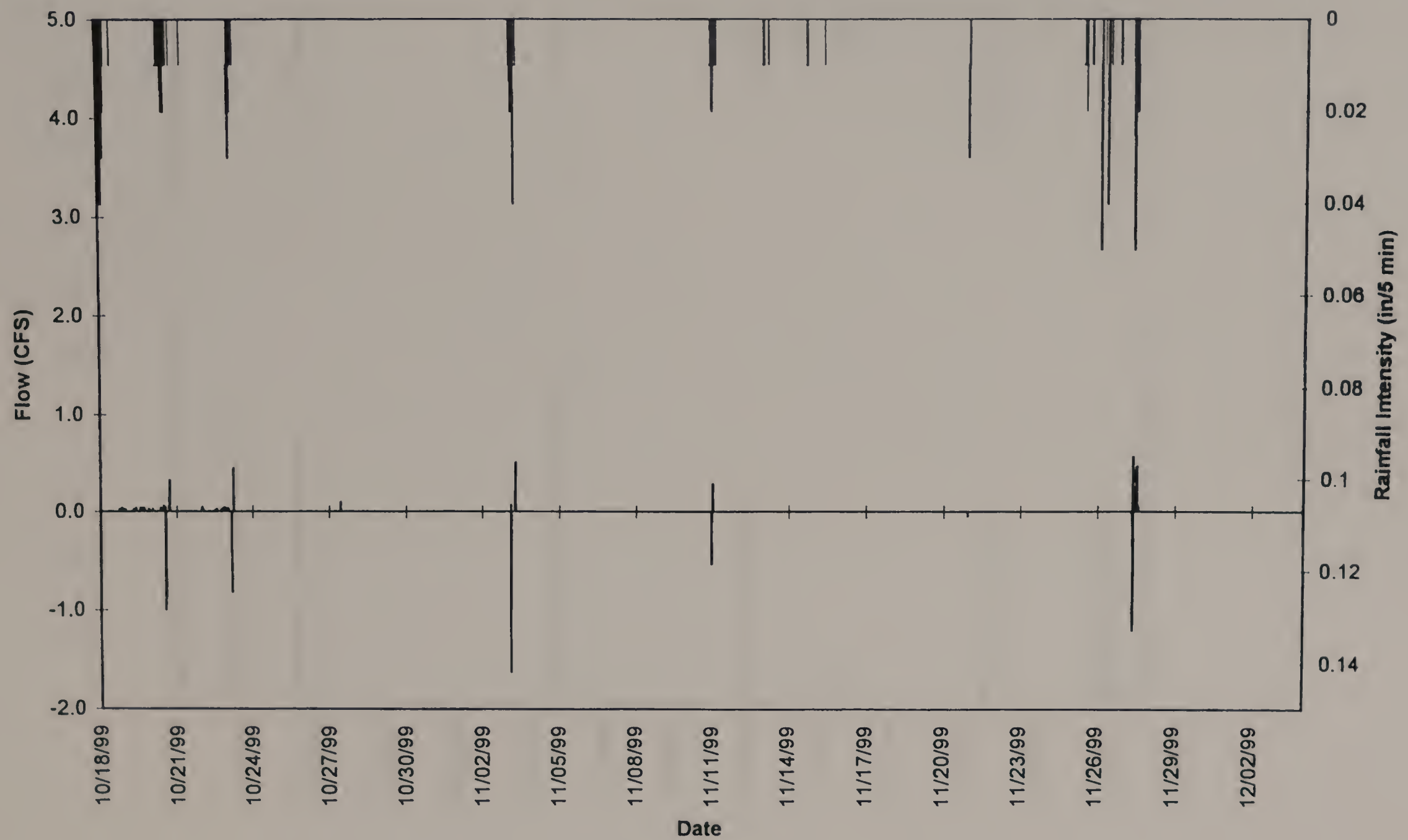
Appendix B

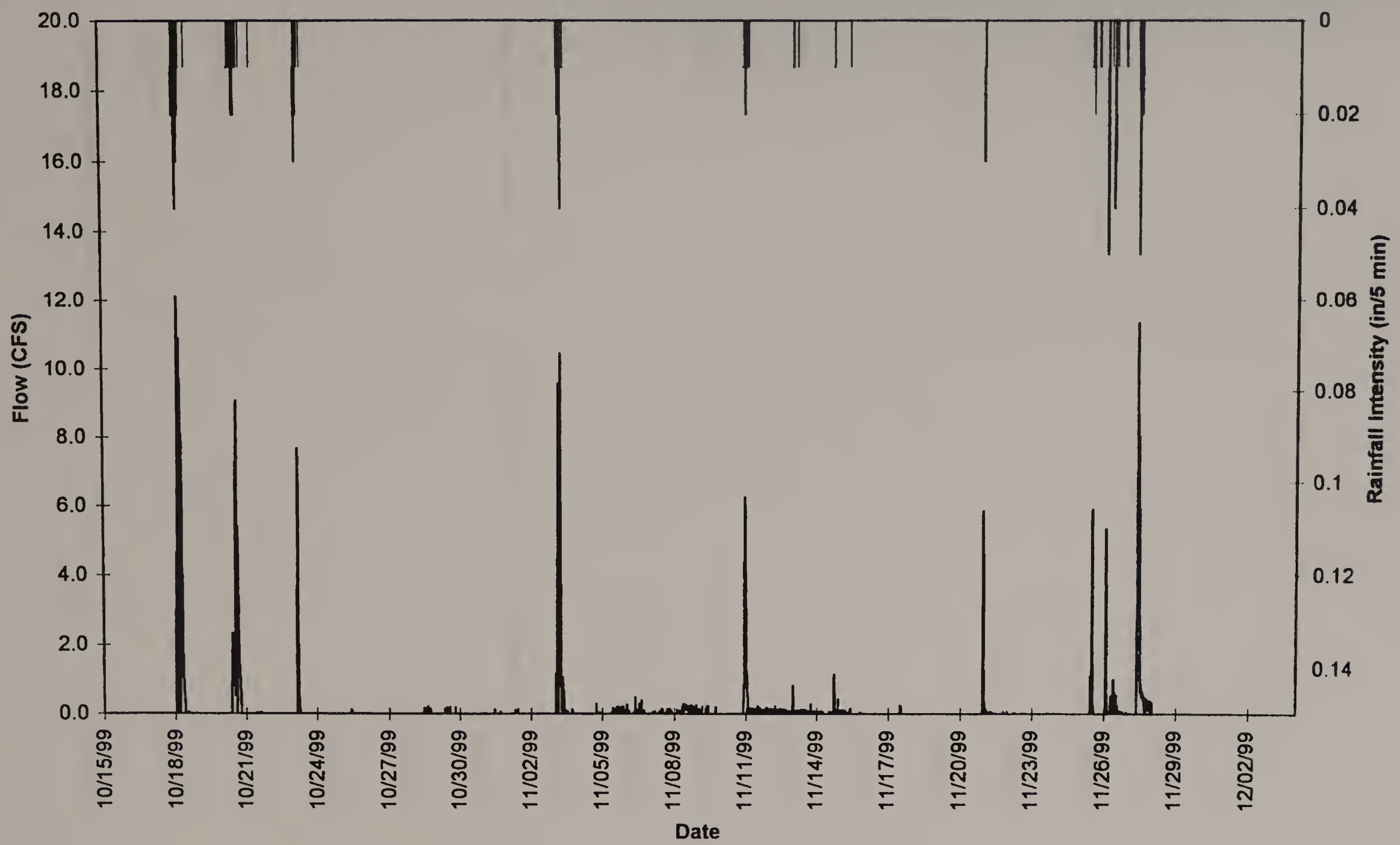
Appendix B

APPENDIX B

FLOW METER DATA


Meter C-4
Flow (CFS)
20
18
16
14
12
10
8
6
4
2
0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/15/99
10/18/99
10/21/99
10/24/99
10/27/99
10/30/99
11/02/99
11/05/99
11/08/99
11/11/99
11/14/99
11/17/99
11/20/99
11/23/99
11/26/99
11/29/99
12/02/99
Date


Meter C-5
Flow (CFS)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/18/99
10/21/99
10/24/99
10/27/99
10/30/99
11/02/99
11/05/99
11/08/99
11/11/99
11/14/99
11/17/99
11/20/99
11/23/99
11/26/99
11/29/99
12/02/99
Date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Flow (CFS)
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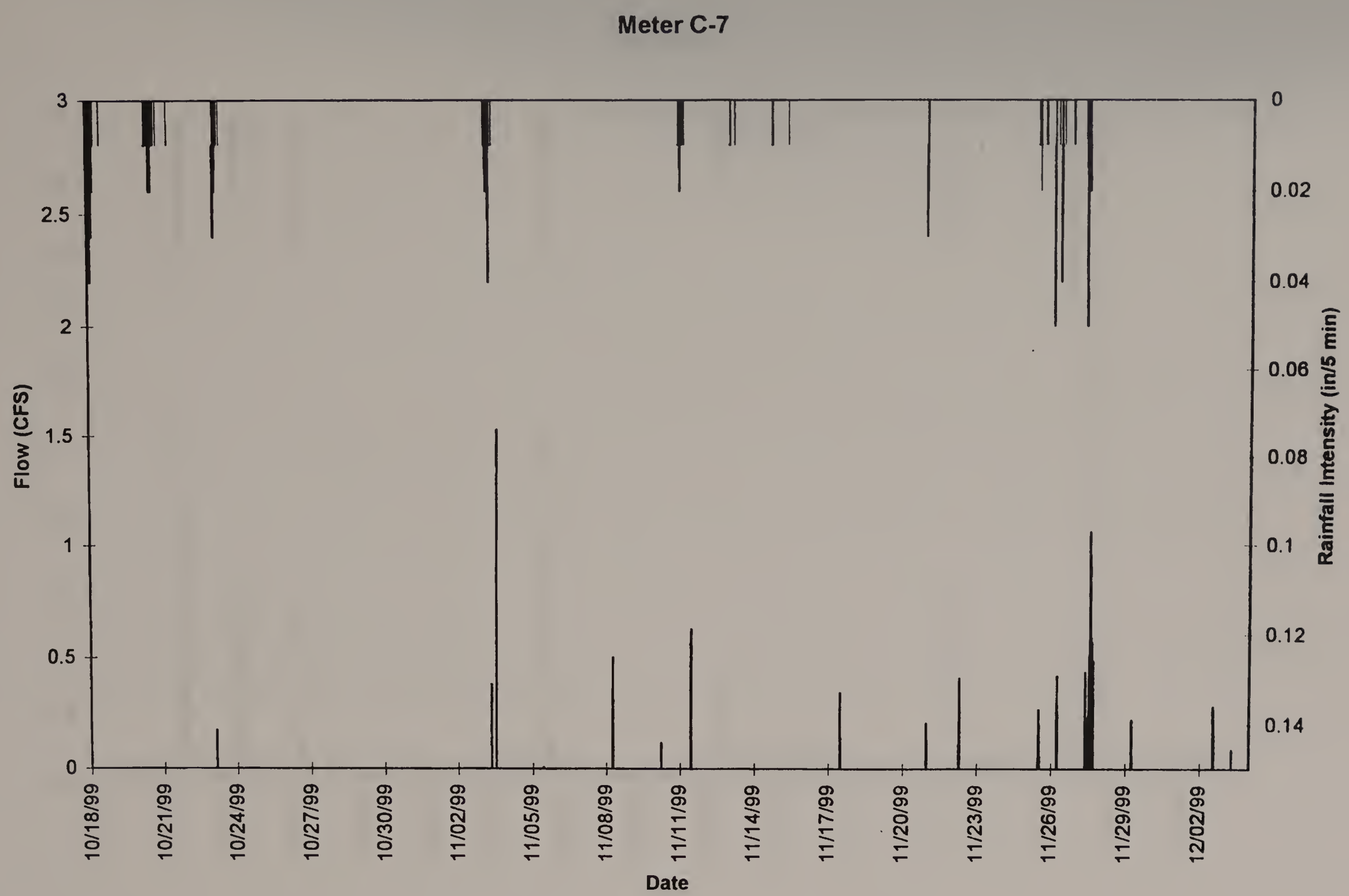
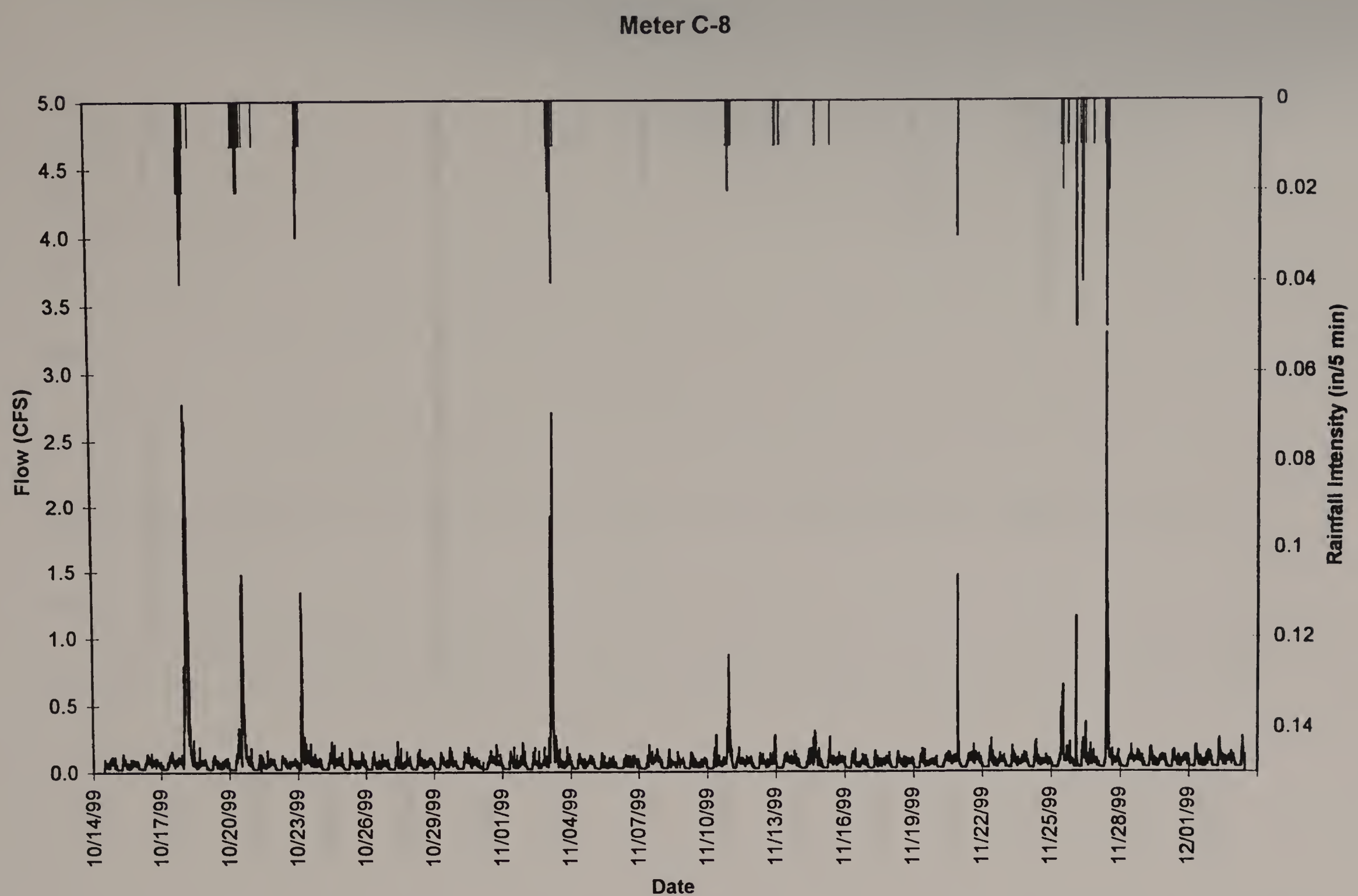
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/15/99
10/18/99
10/21/99
10/24/99
10/27/99
10/30/99
11/02/99
11/05/99
11/08/99
11/11/99
11/14/99
11/17/99
11/20/99
11/23/99
11/26/99
11/29/99
12/02/99
Date


Meter C-7
Flow (CFS)
3
2.5
2
1.5
1
0.5
0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/18/99
10/21/99
10/24/99
10/27/99
10/30/99
11/02/99
11/05/99
11/08/99
11/11/99
11/14/99
11/17/99
11/20/99
11/23/99
11/26/99
11/29/99
12/02/99
Date


Meter C-8
Flow (CFS)
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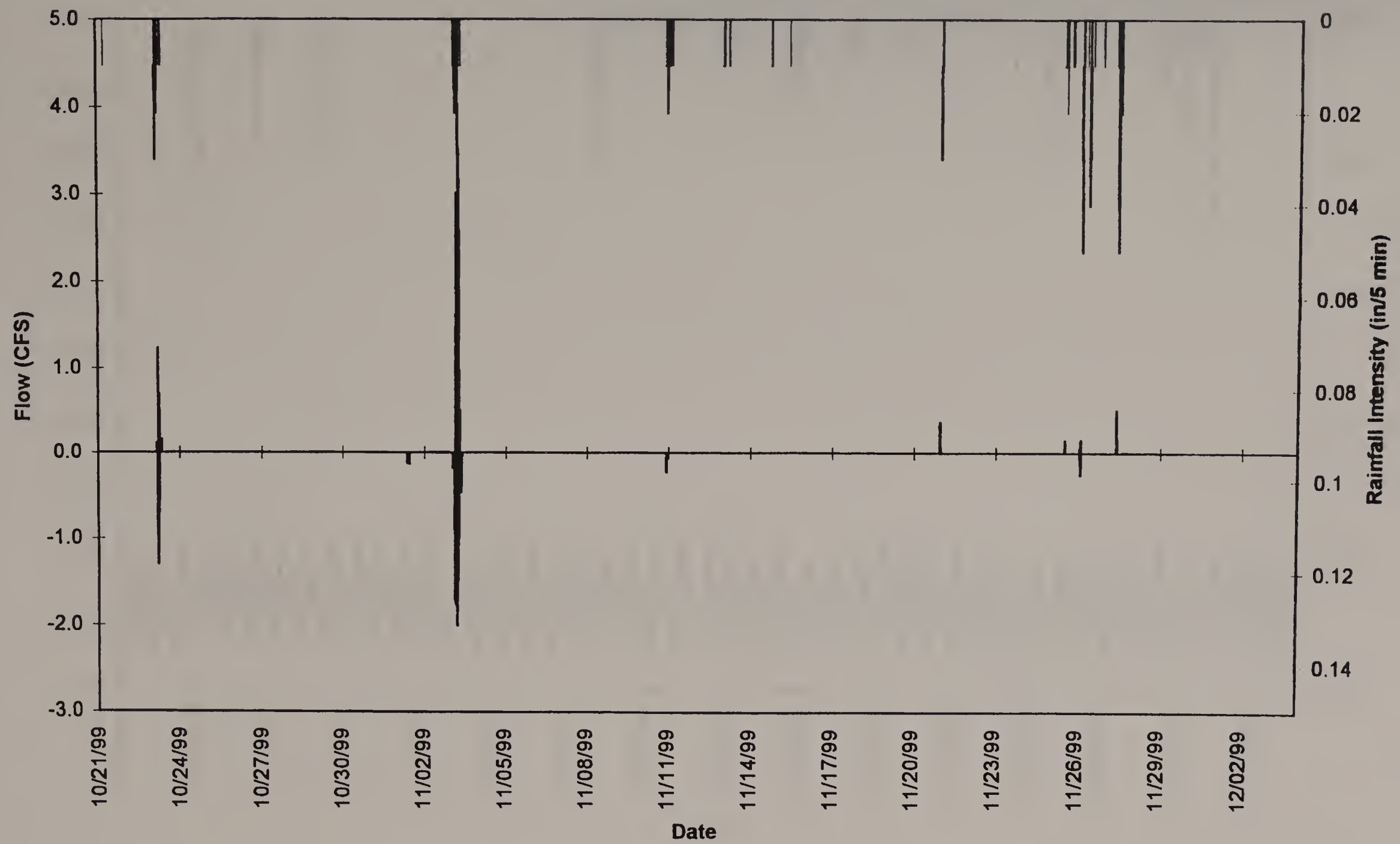
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/14/99
10/17/99
10/20/99
10/23/99
10/26/99
10/29/99
11/01/99
11/04/99
11/07/99
11/10/99
11/13/99
11/16/99
11/19/99
11/22/99
11/25/99
11/28/99
12/01/99
Date


Meter C-9
Flow (CFS)
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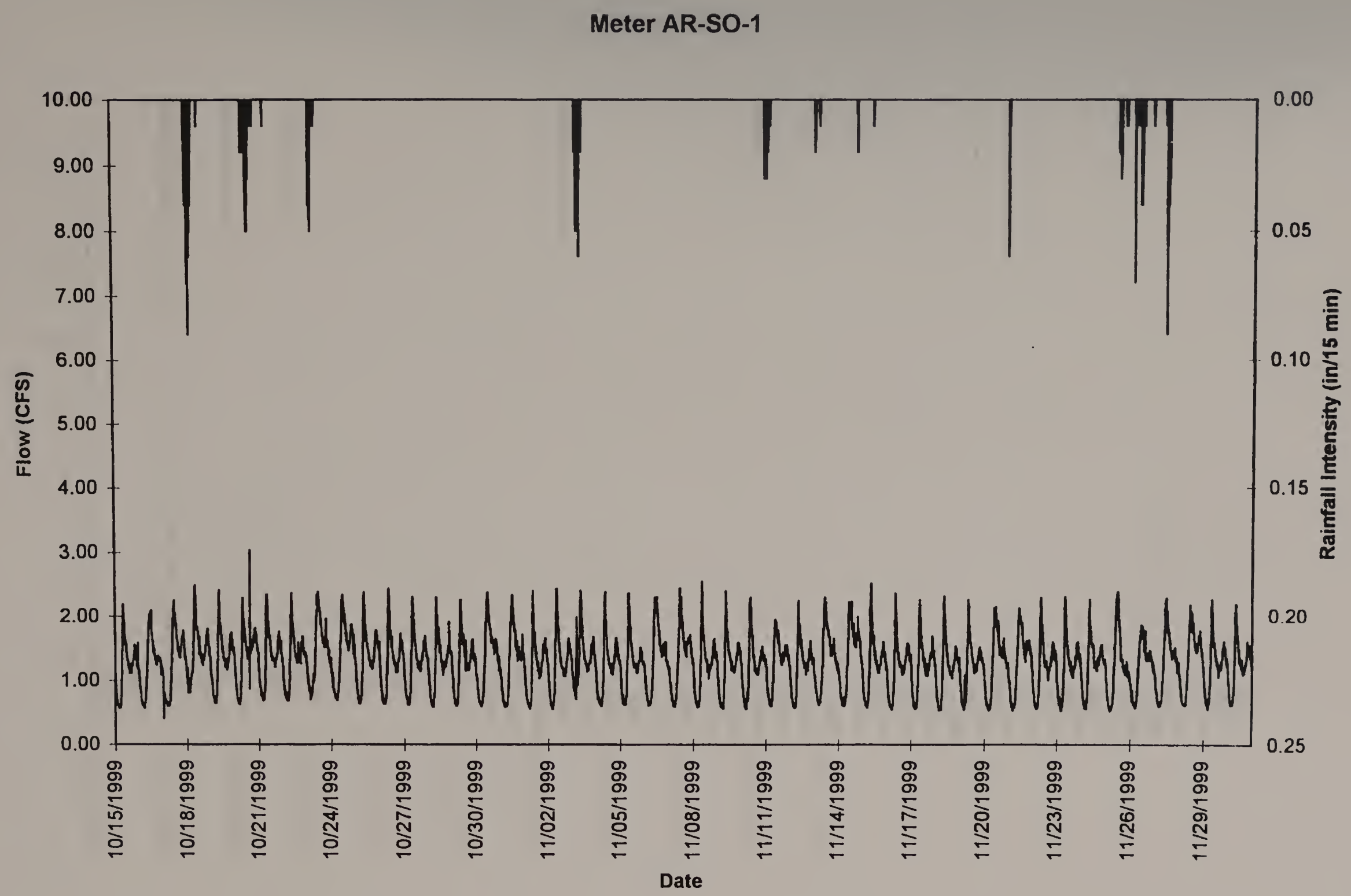
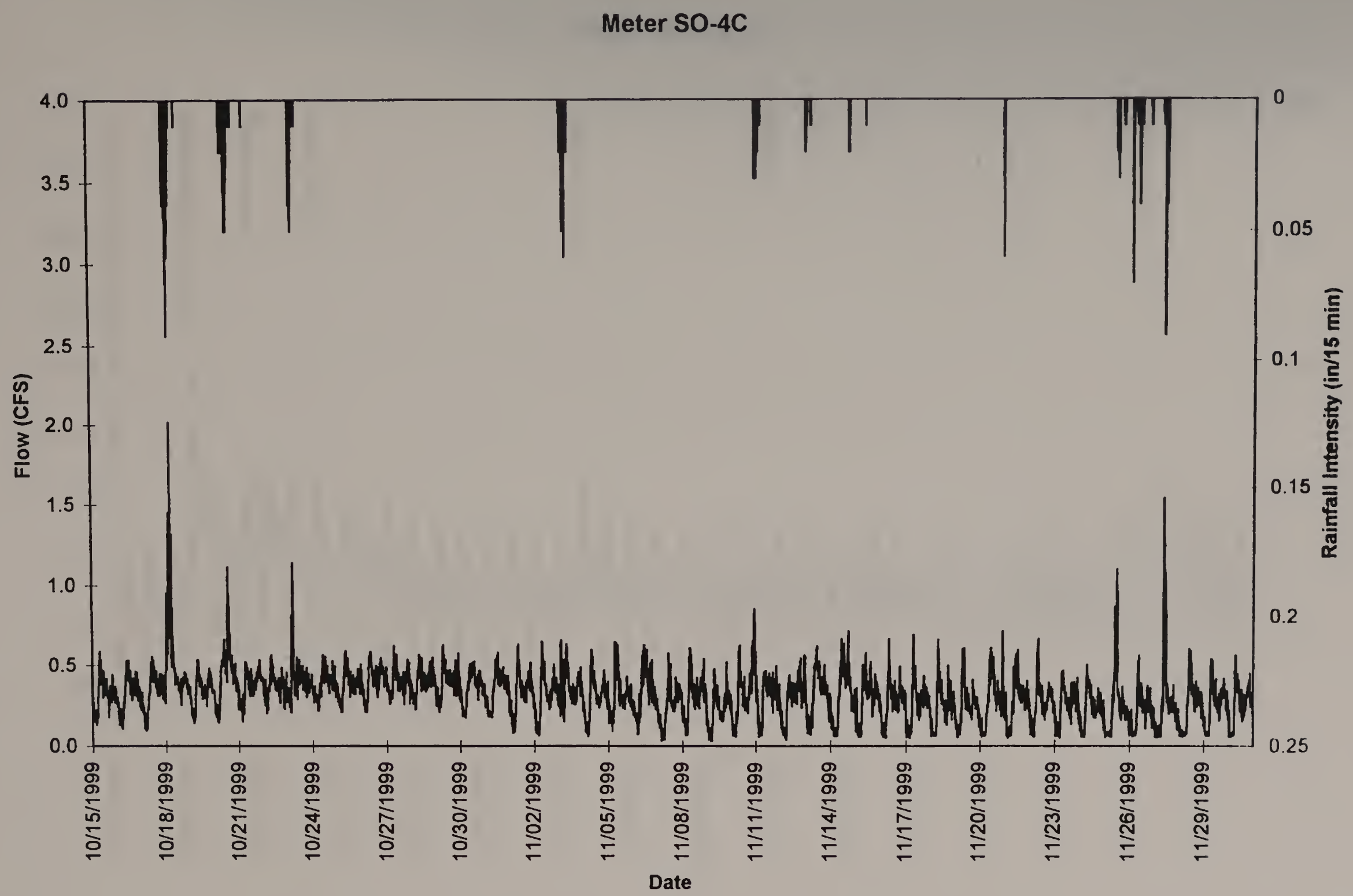
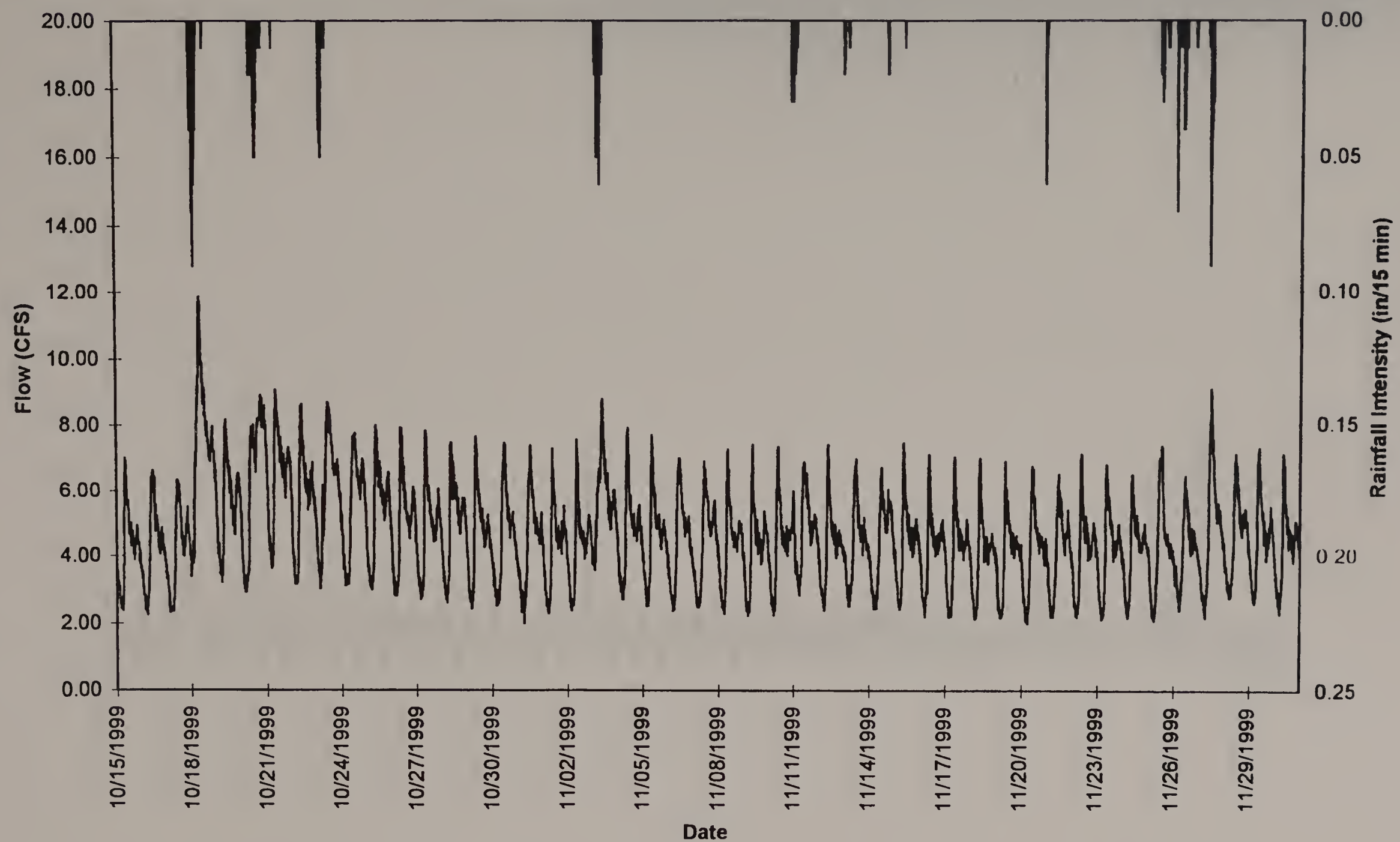
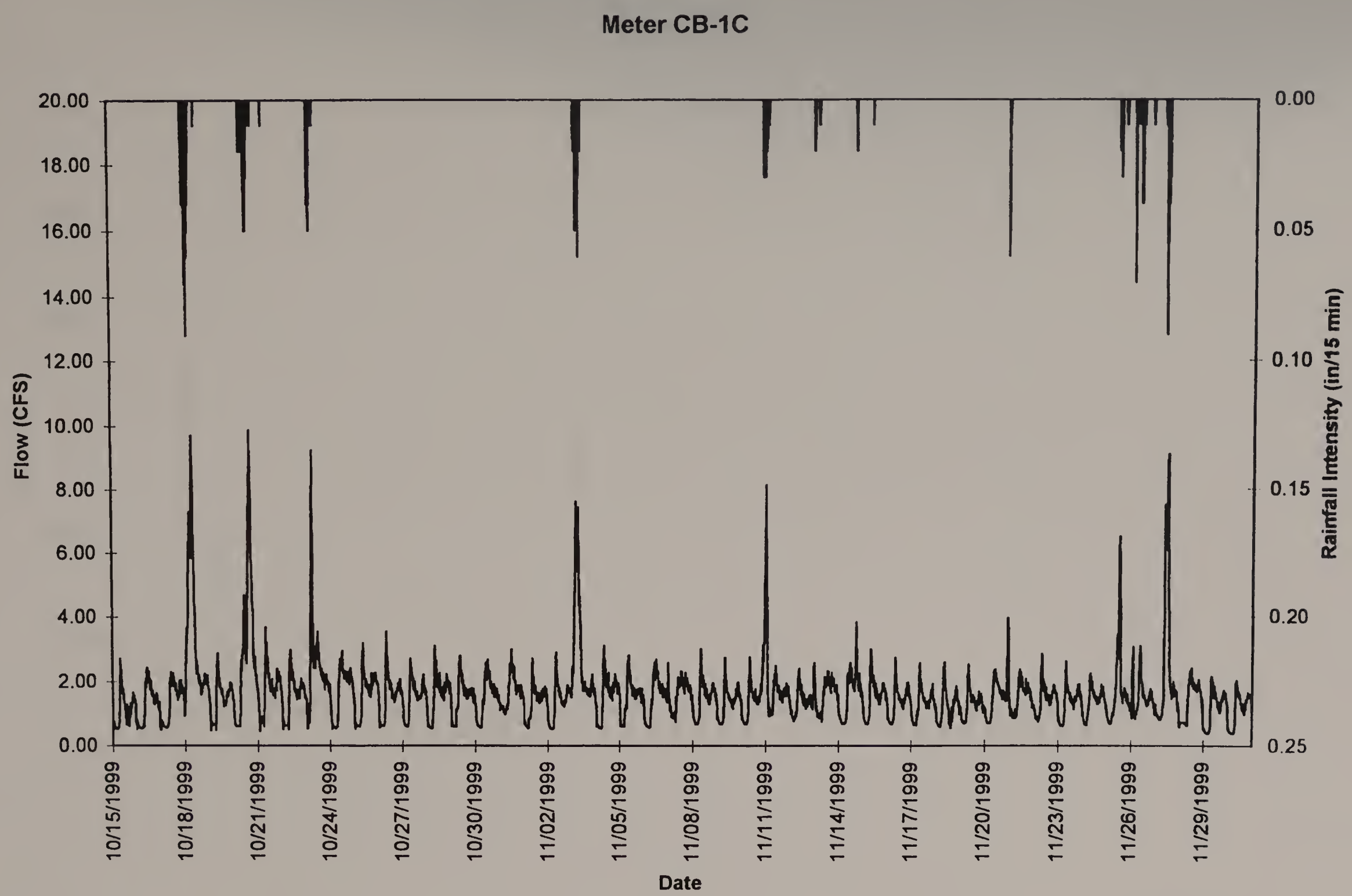
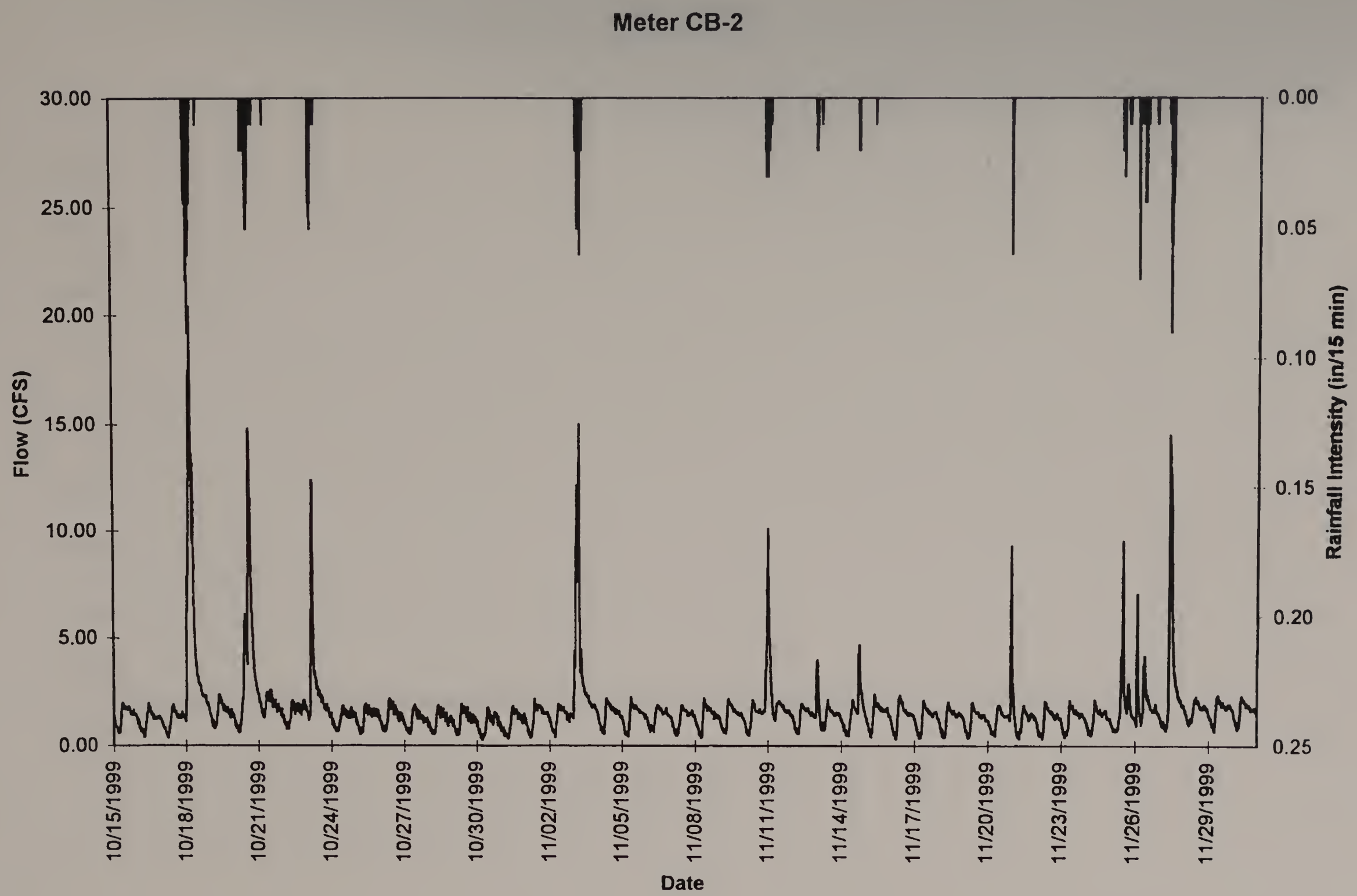
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
Rainfall Intensity (in/5 min)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
10/21/99
10/24/99
10/27/99
10/30/99
11/02/99
11/05/99
11/08/99
11/11/99
11/14/99
11/17/99
11/20/99
11/23/99
11/26/99
11/29/99
12/02/99
Date


Meter AR-SO-1
Flow (CFS)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter SO-4C
Flow (CFS)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Rainfall Intensity (in/15 min)
0
0.05
0.1
0.15
0.2
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter BM-CB-1C
Flow (CFS)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter CB-1C
Flow (CFS)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter CB-2
Flow (CFS)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
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11/26/1999
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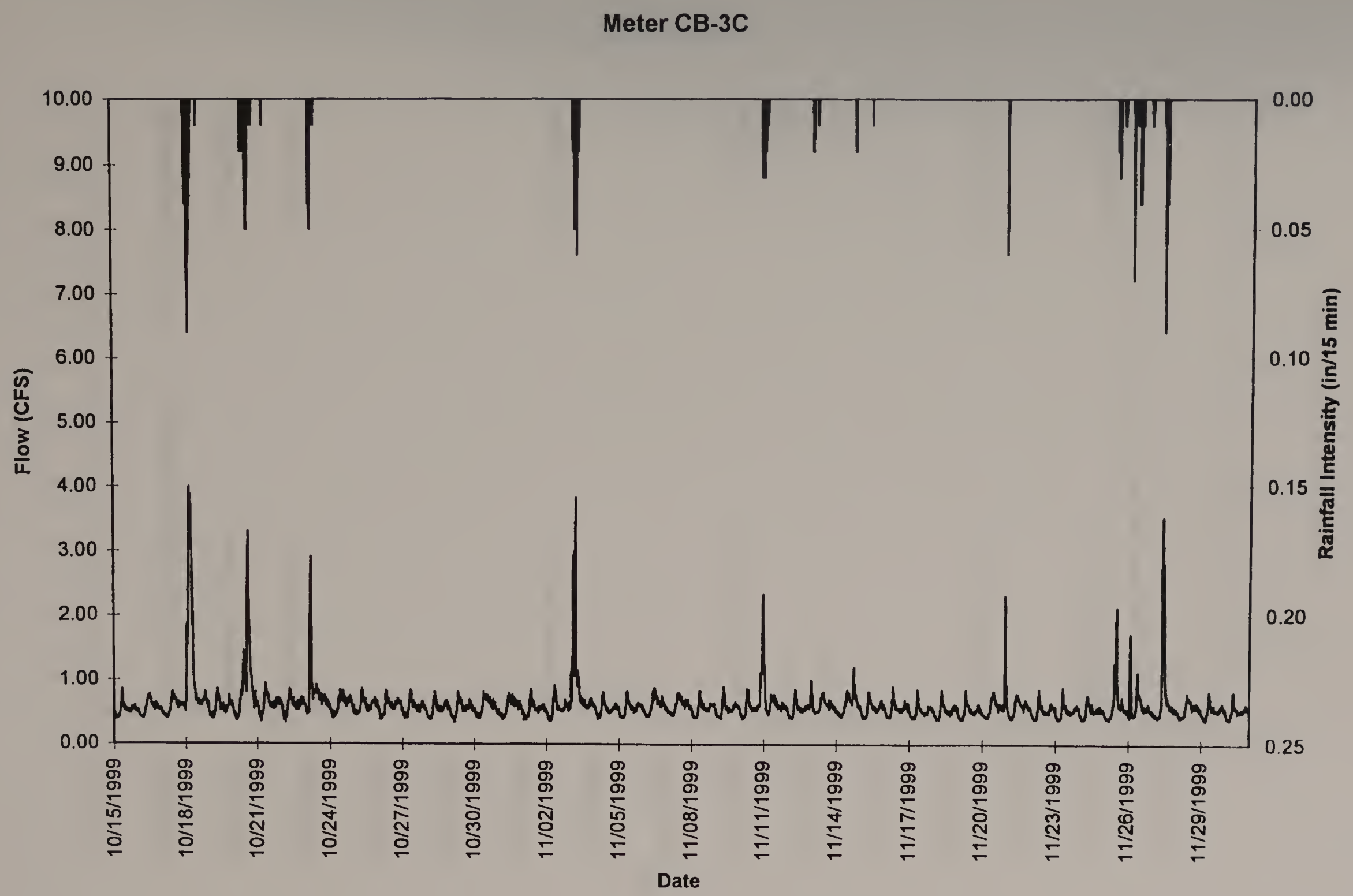
Date


Meter CB-3C
Flow (CFS)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
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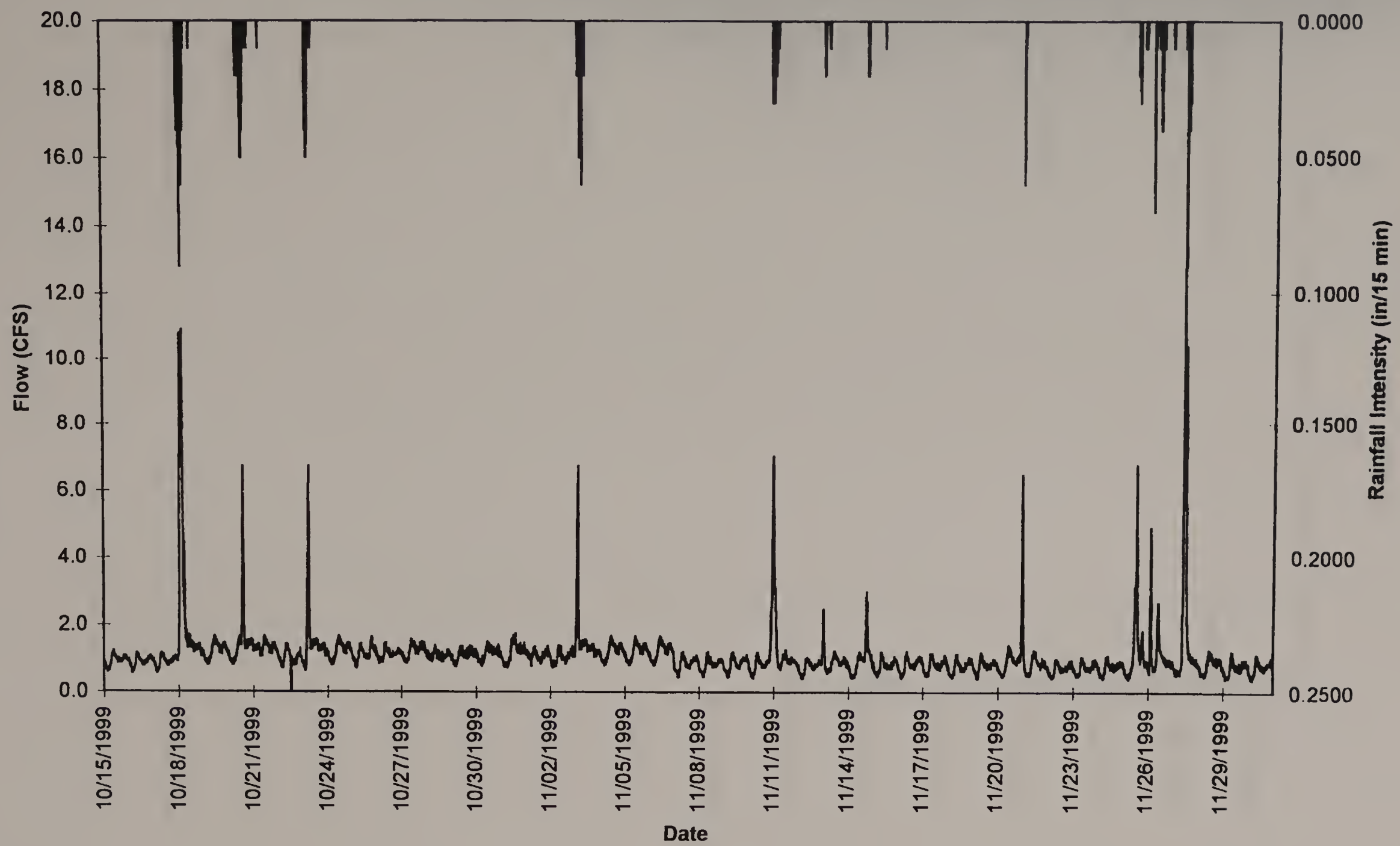
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter CB-4C
Flow (CFS)
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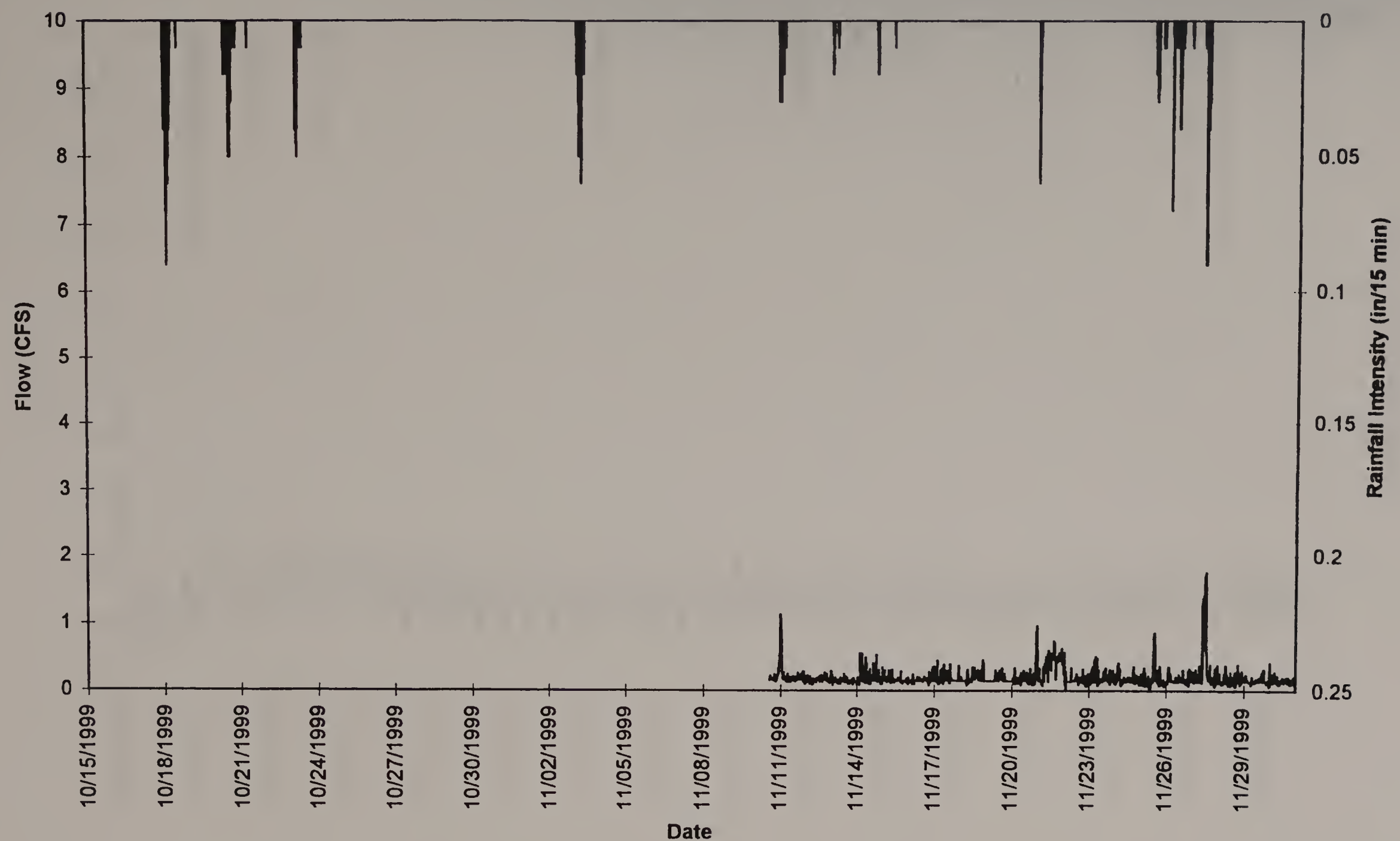
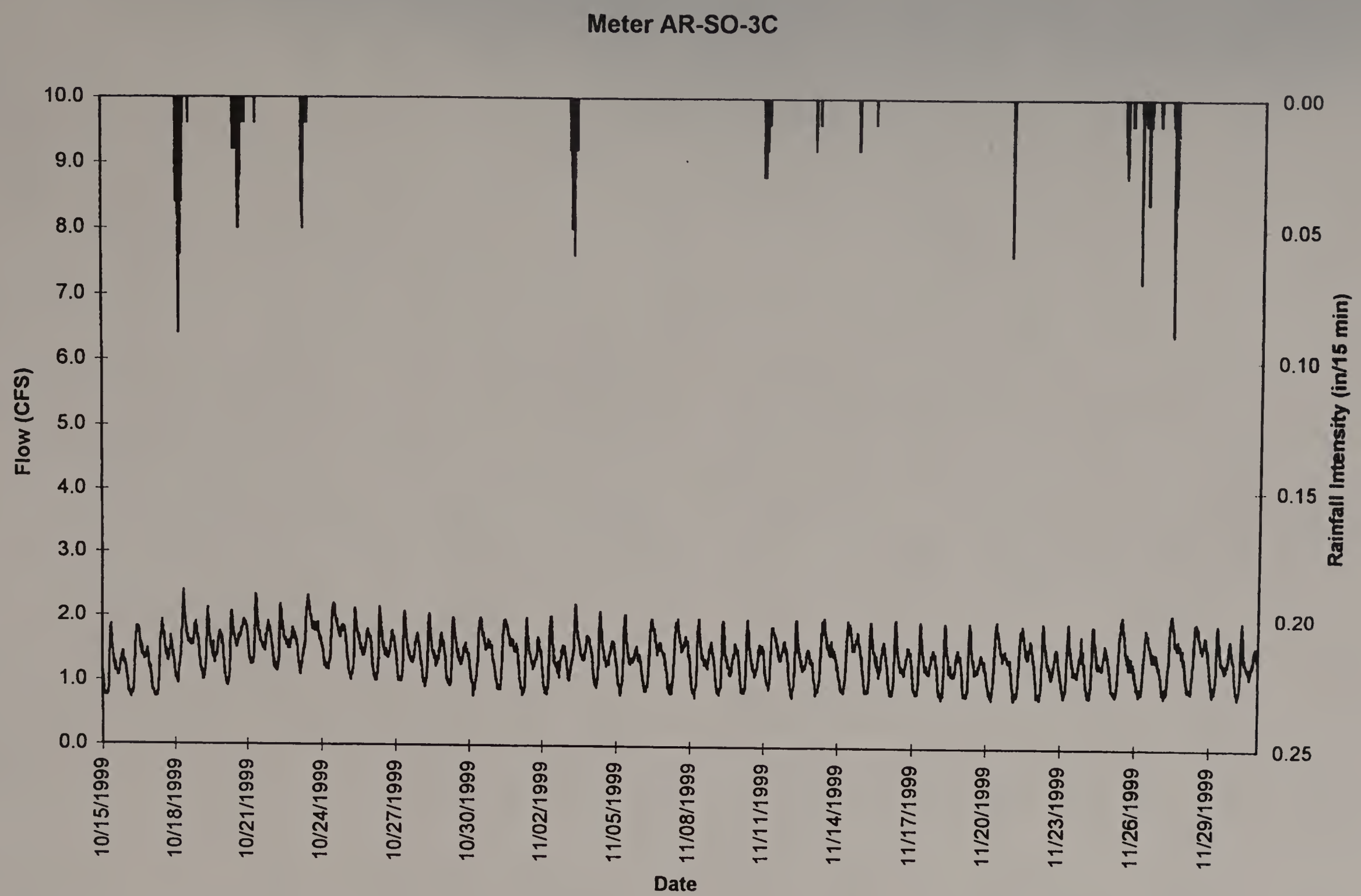
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Rainfall Intensity (in/15 min)
0.0000
0.0500
0.1000
0.1500
0.2000
0.2500
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter CB-5
Flow (CFS)
10
9
8
7
6
5
4
3
2
1
0
Rainfall Intensity (in/15 min)
0
0.05
0.1
0.15
0.2
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date


Meter AR-SO-3C
Flow (CFS)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Rainfall Intensity (in/15 min)
0.00
0.05
0.10
0.15
0.20
0.25
10/15/1999
10/18/1999
10/21/1999
10/24/1999
10/27/1999
10/30/1999
11/02/1999
11/05/1999
11/08/1999
11/11/1999
11/14/1999
11/17/1999
11/20/1999
11/23/1999
11/26/1999
11/29/1999
Date

Appendix C

Appendix C

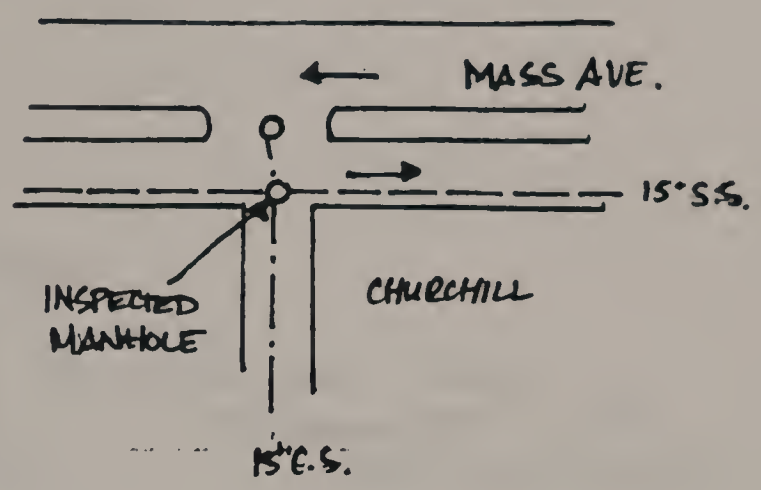
APPENDIX C

FIELD INSPECTION DATA

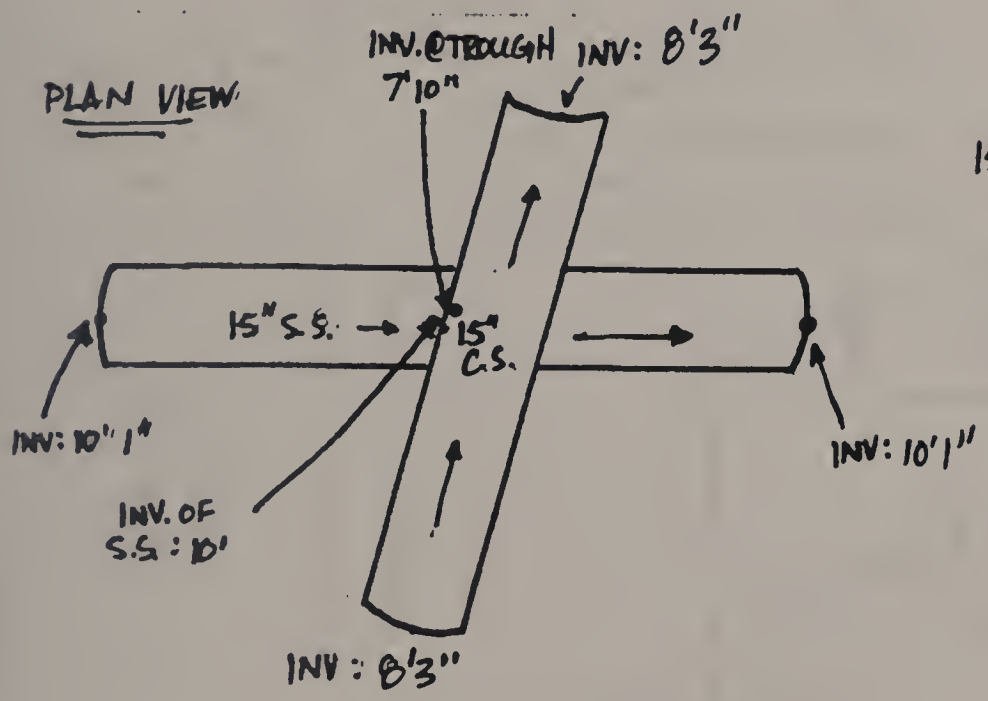
Subject MANHOLE INSPECT.
Detail MASS AVE / CHURCHILL - NTS.
Comptd. By G.GRANT Date 1/11/2000
Ck'd. By Date

MANHOLE INSPECTION
CHURCHILL & MASS AVE.

X-CONNECT BETWEEN CS & SANITARY SYST.

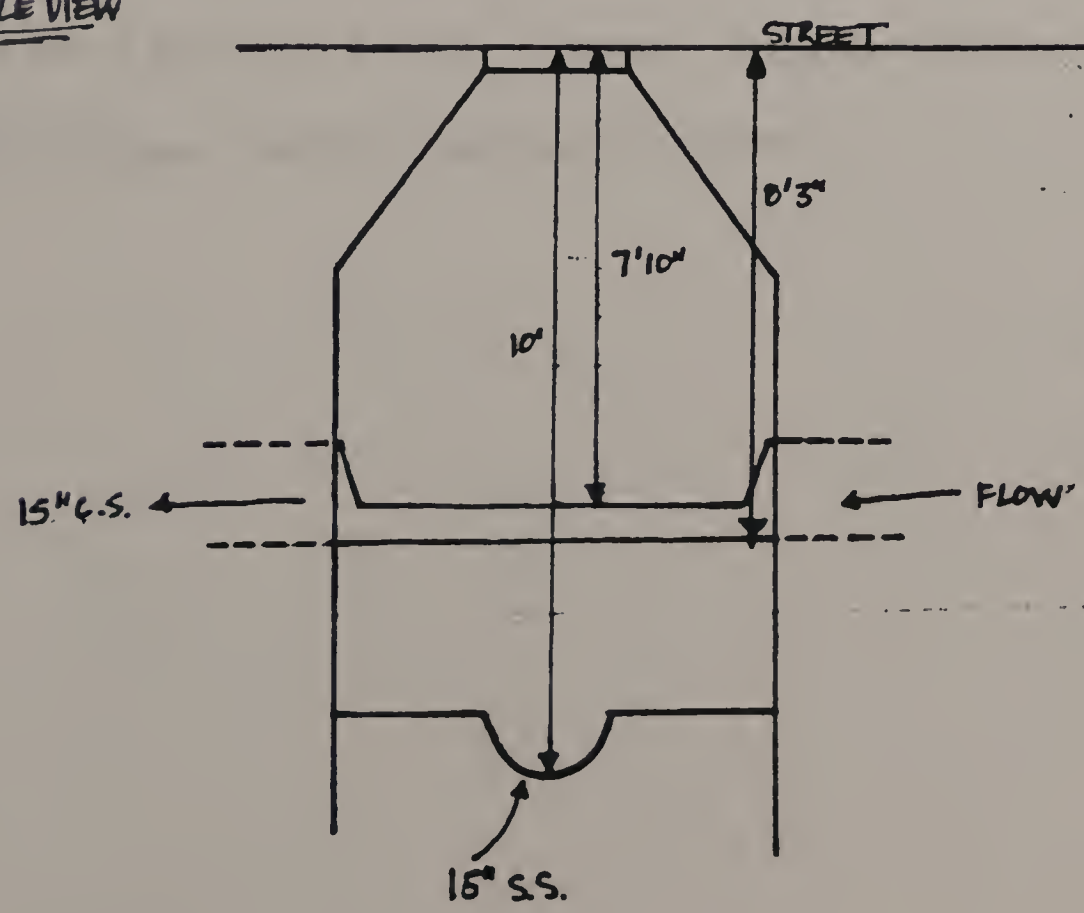


PLAN VIEW



15" C.S. OPEN TROUGH ABOVE 15" S.S. - CAN OF TO S.S. DURING STORM

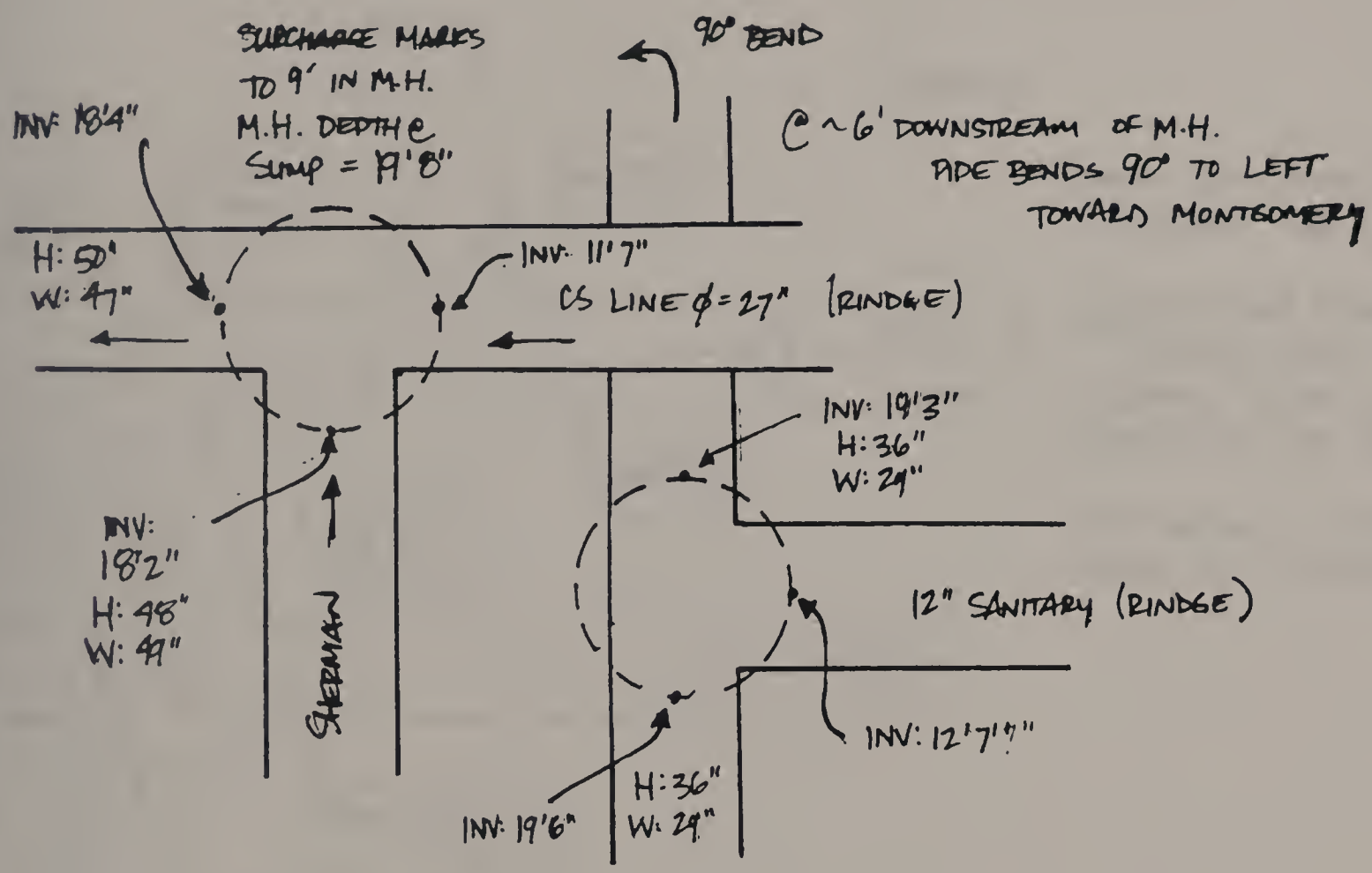
PROFILE VIEW



PROFILE - IN M.H LOOKING TOWARD INTERSECT. OF MASS AVE AND ALEWIFE BK PKY.

Subject MANHOLE INSPECTIONS Comptd. By G. GRANT Date 01/07/2000

Detail SHERMAN | RINDGE — NTS Ck'd. By Date

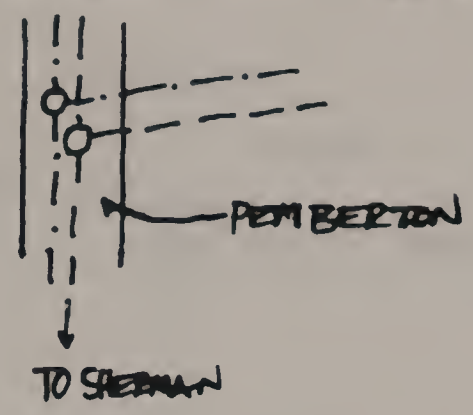


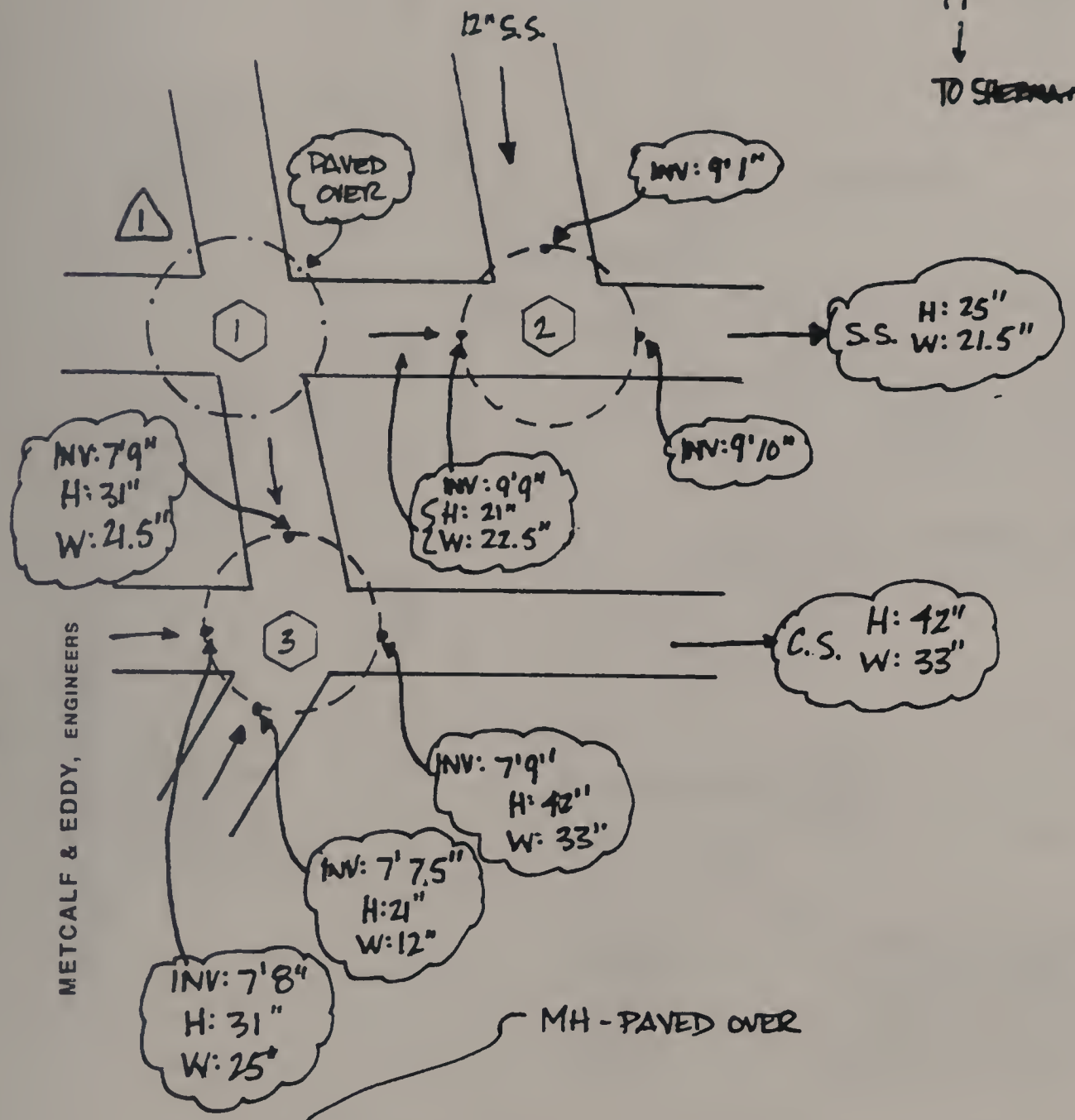
NO X-CONNECT @ THIS LOCATION. SHERMAN ST. SANITARY SYSTEM PASSES BELOW RINDGE COMBINED SYSTEM.

Subject MANHOLE INSPECTIONS
Detail YERYA RD. / PEMBERTON

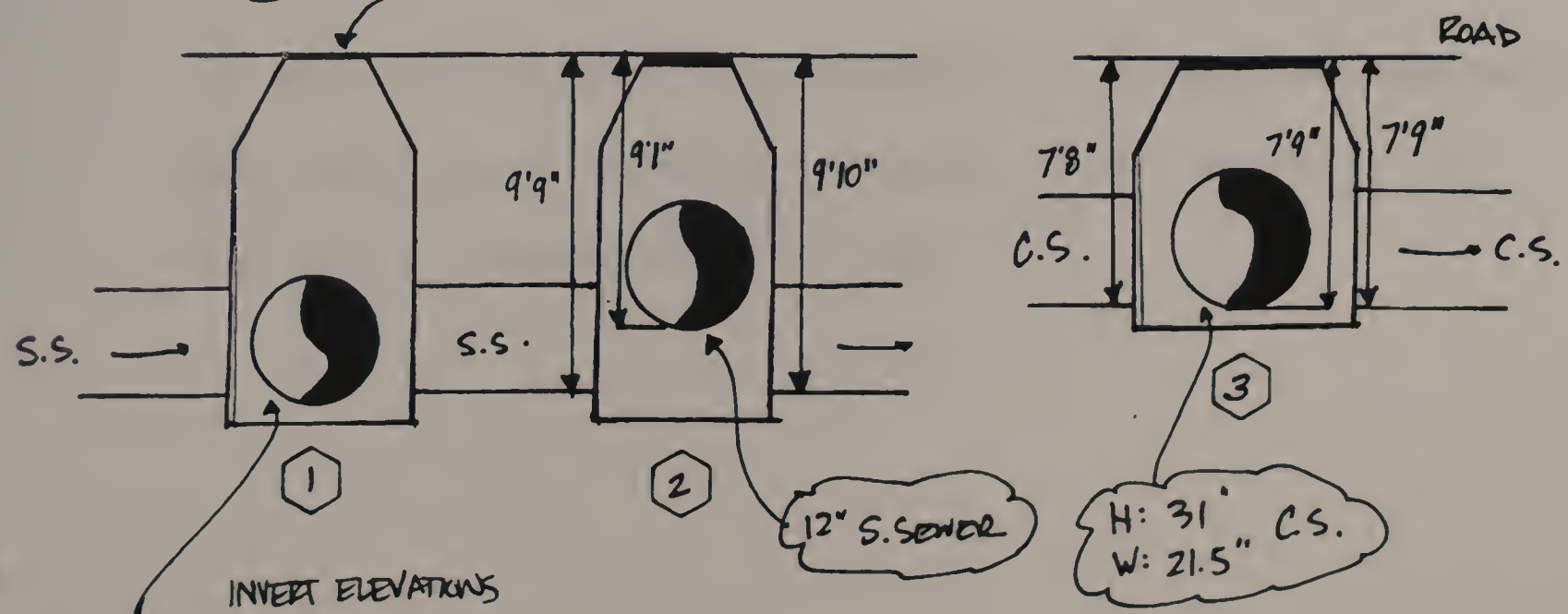
Comptd. By G. GRANT Date 1/12/2000
Ck'd. By Date

MANHOLE INSPECTIONS
YERYA RD. / PEMBERTON





- INVERT ELEVATIONS FOR X-CONNECT ARE UNKNOWN
- 1 MH HAS BEEN PAVED OVER – UPS INSPECT. SHOWS STRUCTURE TO EXIST
- NOT KNOWN IF WEIRS EXIST ON X-CONNECT

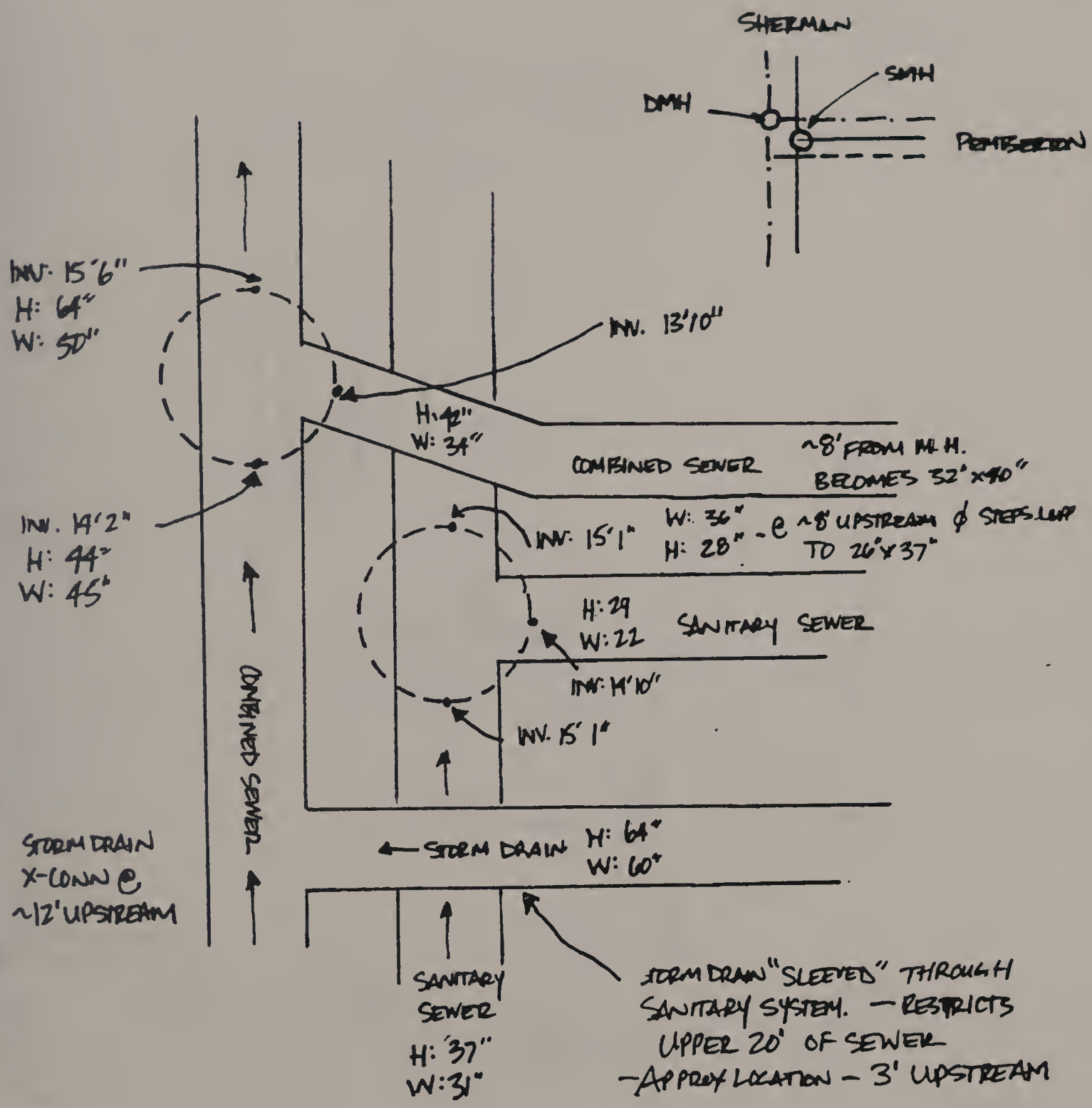


INVERT ELEVATIONS UNKNOWN

C.S. CROSS-CONNECT
– ACTUAL ARRANGEMENT UNKNOWN

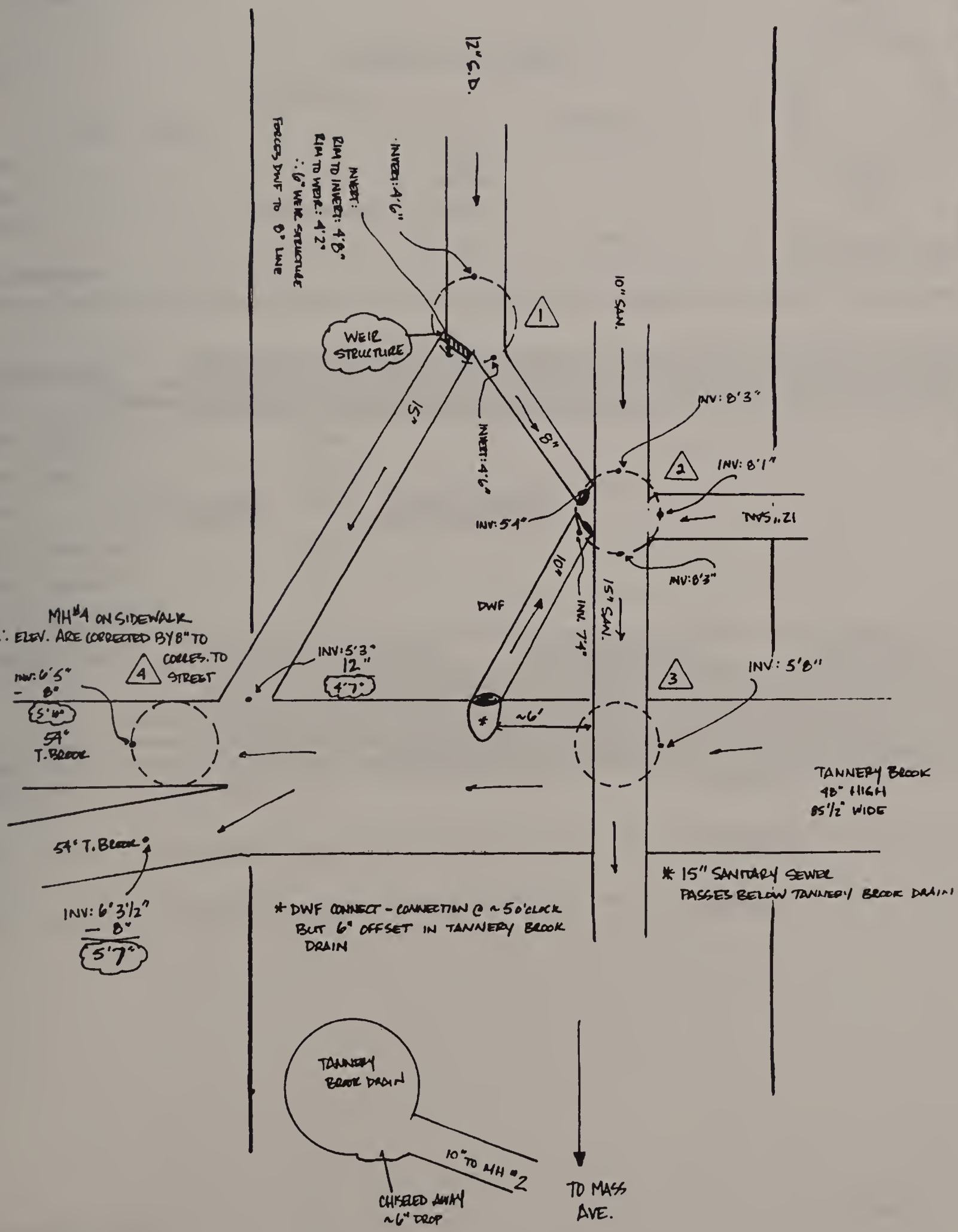
Subject MANHOLE INSPECTIONS Comptd. By G. GRANT Date 1/17/2000

Detail PEMBERTON / SHERMAN Ck'd. By Date



NO CROSS CONNECTS EXIST @ THIS INTERSECTION. SD FROM PEMBERTON DOES ENTER CS ON SHERMAN. HOWEVER SD DOES NOT X-CONN W/ SANITARY — SLEEVED THROUGH PIPE.

METCALF & EDDY ENGINEERS



Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: 140 SHERMAN STREET
Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 36 **Time:**

Manhole No.: CAM 401
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Cover & Adjacent Area Comments:

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)		
Lift Hole(s)	1	2
Other Hole(s)		

COVER INFLOW POTENTIAL

Drainage Area 1:

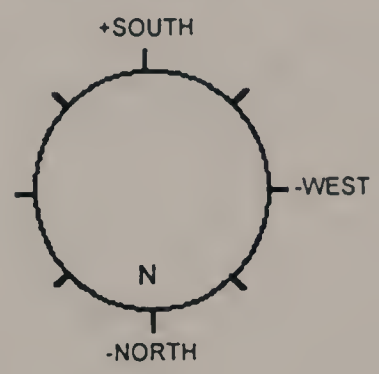
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NORTH

General Comments:

CSO Structure. Pipe dimensions above weir structure, Photo #1-- 42"h x96"w. Photo #2-- influent from south. Photo #3-- effluent to north.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS		NONE			
WALLS	BRICK, PIP	GOOD			
FLOOR	UNKNOWN	CNI			
INVERT	UNKNOWN	CNI			

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SOUTH	11' 8"	46H45W	BRK		11	3		2	SLOW FLOW
OUT TO	NORTH	12' 3"	64H60W	CONC		16	5		3	SLOW FLOW
OUT TO	WEST	11' 6"	74H96W	CONC		0	0		1	WEIR WALL

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: 147 PEMBERTON STREET
Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 40 **Time:**

Manhole No.: 1
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)	0	0
Other Hole(s)	0	0

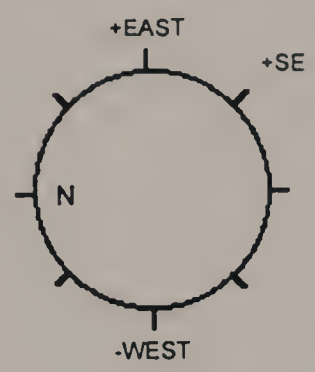
Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:
2 X 2 X 0.9 = 3.60 (SQFT)
Runoff Coefficient

Drainage Area 2: (if applicable)
X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: WEST

General Comments:
Sanitary Sewer MH. Photo #4- Influent from east.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS	BRICK	POOR			
WALLS	BRICK	GOOD			
FLOOR	BRICK	GOOD			
INVERT	BRICK + PIP	GOOD			

Surcharge From Invert: NONE EVIDENT **Currently:** Feet **Marks To:** Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SE	9' 1"	12	VCP	2	2	0			Heavy Mineral deposits beginning @ 4'
IN FROM	EAST	9' 9"	21H23W	PIP, BRICK		4	3.5		4	@ 3', buried MH w/ 31" x 21.5" brick line @ 3 o'clock
OUT TO	WEST	9' 10"	25H22W	PIP, BRICK		8.5	0			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: 147 PEMBERTON STREET
Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 40 **Time:**

Manhole No.: 2
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ **CNL:** ☐ **CNI:** ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)	0	0
Other Hole(s)	0	0

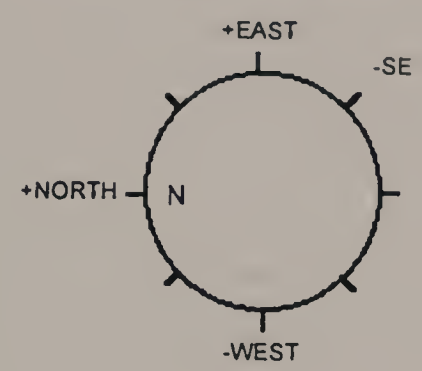
Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:
2 X 2 X 0.9 = 3.60 (SQFT)
Runoff Coefficient

Drainage Area 2: (if applicable)
X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: WEST

General Comments:
Combined Sewer MH. Photo #5- Effluent line to SE.

Clear Opening Dia.: In. ***INTERNAL MANHOLE OBSERVATIONS:***

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	FAIR			MISSING BRICKS
STEPS	BRICK	POOR			
WALLS	BRICK	GOOD			
FLOOR		NONE			
INVERT	BRICK	FAIR			MISSING MORTAR

Surcharge From Invert: NONE EVIDENT **Currently:** Feet **Marks To:** Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	NORTH	7' 8"	21H12W	BRK		0	3			Bulkheaded @ 1'.
IN FROM	EAST	7' 8"	31H25W	BRK		1.5	0			@ 20' bisc @ 9 o'clock, running 3 gpm (clear)
OUT TO	WEST	7' 9"	42H33W	BRK		3	0			@ 4', BISC @ 2+10 o'clock
OUT TO	SE	7' 9"	31H21.5	BRK		2	1		5	@ 10' enters sanitary conduit in buried mh.

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: PEMBERTON STREET @ SHERMAN STREET
Manhole No.: 3
Sub-System: NA
Common Manhole: ☐

Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 46 **Time:**

COVER CHARACTERISTICS

Cover & Adjacent Area Comments:

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT

Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	1	2
Lift Hole(s)		
Other Hole(s)		

COVER INFLOW POTENTIAL

Drainage Area 1:

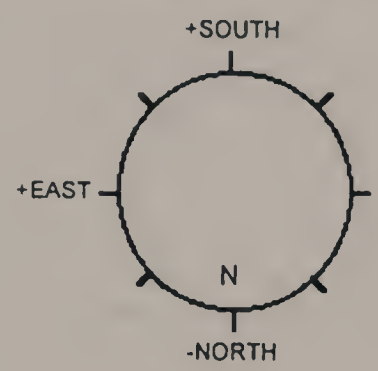
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NORTH

General Comments:

Combined Sewer MH. Photo #6 - influent from the south. Photo #7 - effluent.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	FAIR			MISSING MORTAR; LOOSE BRICKS
STEPS	BRICK	POOR			
WALLS	BRICK	GOOD			
FLOOR	BRICK	GOOD			
INVERT	BRICK	GOOD			

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	EAST	14' 10"	29H22W	BRK, PIP		6	3			
IN FROM	SOUTH	15' 1"	36H28W	BRK		8	4.5		6	@ 3', conc. conduit restricts upper half of sewer.
OUT TO	NORTH	15' 1"	31H37W	BRK, PIP		12.5	1		7	@ 8' changes to 36h x 27w

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: PEMBERTON STREET @ SHERMAN STREET
Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 46 **Time:**

Manhole No.: 4
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)		
Lift Hole(s)	1	2
Other Hole(s)	24	0.5

Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:

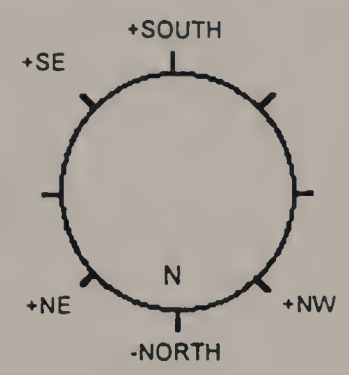
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NORTH

General Comments:

Combined Sewer MH. Influent from the south, @ 12' a 64"h x 72"w brick and concrete conduit enters @ 9 o'clock. (Photos 8 & 9)

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS		NONE			
WALLS	BRICK	GOOD			
FLOOR	UNKNOWN	CNI			
INVERT	UNKNOWN	CNI			

Surcharge From Invert: NONE EVIDENT **Currently:** Feet **Marks To:** Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	NE	5' 4"	10	CONC	1	0	0			@ 1' changes to 8" vcp.
IN FROM	NW	5' 5"	10	CONC	1	0	0			Bulkheaded @ 1'
IN FROM	SE	13' 10"	42h34w	BRK, CONC		1	0			@8', changes to 40"h x 32"w brick
IN FROM	SOUTH	14' 2"	44h45w	BRK		11	3		8,9	@ 12' changes to 64"h x 60"w rectangular conc.
OUT TO	NORTH	15' 6"	64h50w	BRK, CONC		14	14			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: SHERMAN STREET @ RINDGE STREET
Manhole No.: 5
Sub-System: NA
Common Manhole: ☐

Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 46 **Time:**

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)		
Other Hole(s)		

Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:

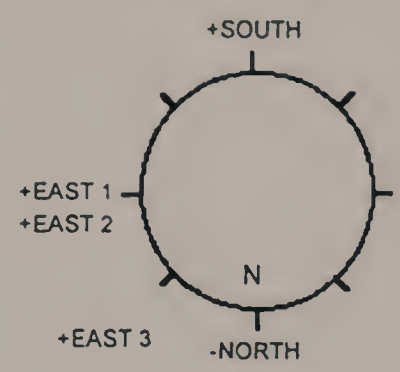
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NORTH

General Comments:
Sanitary Sewer MH.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS	BRICK	POOR			
WALLS	BRICK	FAIR			MISSING MORTAR
FLOOR	BRICK	GOOD			
INVERT	POURED IN PLACE	GOOD			

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SOUTH	19' 6"	36H29W	BRK, PIP		8	9			
IN FROM	EAST 1		8	ACP	6	0	8			full pipe of debris @ 8'.
IN FROM	EAST 2	12' 7"	12	VCP	2	2	5			OUTSIDE DROP
IN FROM	EAST 3		6	VCP	1	0	0			BULKHEADED @ 1'.
OUT TO	NORTH	19' 3"	36H29W	BRK, PIP		8	9			@ 6', makes 90 degree to the left

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: SHERMAN STREET @ RINDGE STREET
Manhole No.: 6
Sub-System: NA
Common Manhole: ☐

Inspection Date: 01/11/2000 **Inspector:** GW **Map #:**
Weather: CLEAR **Temp:** 46 **Time:**

COVER CHARACTERISTICS

Cover & Adjacent Area Comments:

Buried: ☐ **CNL:** ☐ **CNI:** ☐

Grade: AT
Amount: In.

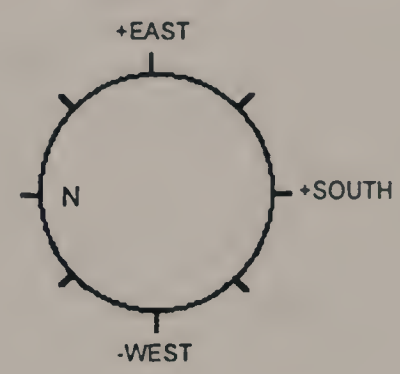
	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)		
Other Hole(s)		

COVER INFLOW POTENTIAL

Drainage Area 1:
2 X 2 X 0.9 = 3.60 (SQFT)
Runoff Coefficient

Drainage Area 2: (if applicable)
X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: WEST

General Comments:
Combined MH.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			MISSING MORTAR, MISSING BRICKS
STEPS	BRICK	POOR			
WALLS	PRECAST	GOOD			
FLOOR	UNKNOWN	CNI			WATER,DEBRIS
INVERT	UNKNOWN	CNI			WATER,DEBRIS

Surcharge From Invert: **Currently:** Feet **Marks To:** 9 Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SOUTH	18' 2"	48H49W	BRK		17	3			
IN FROM	EAST	11' 7"	27	CIP	4	1	0			
OUT TO	WEST	18' 4"	50H47W	BRK		20	0			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: MASSACHUSETTS AVENUE @ CHURCHILL AVENUE
Manhole No.: 7
Sub-System: NA
Common Manhole: ☐

Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLOUDY **Temp:** 38 **Time:**

COVER CHARACTERISTICS

Cover & Adjacent Area Comments:

Buried: ☐ CNL: ☐ CNI: ☐

Grade: BELOW
Amount: 1 In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)		
Other Hole(s)		

COVER INFLOW POTENTIAL

Drainage Area 1:

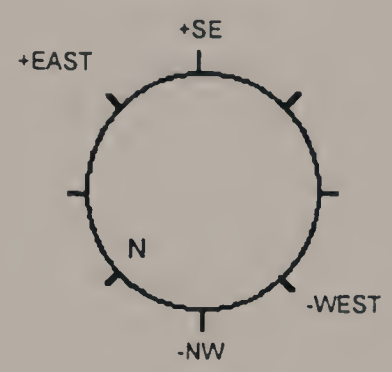
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NW

General Comments:

Sanitary MH with combined sewer line passing through. Highest point of broken-out invert is 7'8" below rim. Lowest point-- 7'10". (Photo #10 View from top of Manhole).

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS	CAST IRON	FAIR			CORRODED
WALLS	BRICK	GOOD			
FLOOR	BRICK	FAIR			MISSING MORTAR; LOOSE BRICKS
INVERT	BRICK	FAIR			BROKEN BRICKS

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	EAST	8' 3"	15	VCP	2	2	1			COMBINED LINE
IN FROM	SE	10' 1"	15	VCP	2	2	0			@ 0.5', 8" BISC in crown is bulkheaded
OUT TO	WEST	8' 3"	15	VCP	2	1.5	1			3" hole in crown at 2': 3" circular crack @ 3'. combined line
OUT TO	NW	10' 0"	15	VCP	2	1.5	0			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: CLARENDON AVENUE
Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLOUDY **Temp:** 38 **Time:**

Manhole No.: 8
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)	0	0
Other Hole(s)	0	0

Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:

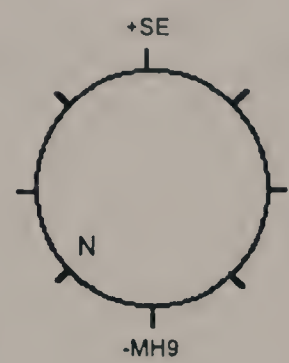
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: MH9

General Comments:

Storm drain manhole. Influent - Photo 11; Effluent - Photo 12.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	GOOD			
STEPS		NONE			
WALLS	BRICK	GOOD			
FLOOR	NONE				
INVERT	POURED IN PLACE	GOOD			

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS:

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SE	5' 8"	48H85.5	BRK, PIP		1.5	0		11	SC @ 5' @ 2:00 ; SC @ 6' @ 3:00 bulkheaded @ 2'
OUT TO	MH9	5' 8"	48H85.5	BRK, PIP		1.5	0		12	SC @ 6' @ 5:00; SC @ 1' @ 9:00 bulkheaded @ 3'

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: CLARENDON AVENUE
Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLOUDY **Temp:** 38 **Time:**

Manhole No.: 9
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	2	1
Lift Hole(s)	1	2
Other Hole(s)	0	0

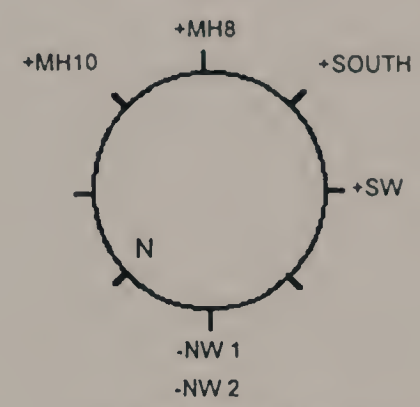
Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:
X X 0.9 = (SQFT)
Runoff Coefficient

Drainage Area 2: (if applicable)
X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: NW

General Comments:
Storm drain manhole; Influent - Photo #13 ; Effluent - Photo #14

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK/CONCRETE	FAIR			MISSING MORTAR
STEPS	CAST IRON	POOR			ROTTED
WALLS	BRICK	GOOD			
FLOOR	BRICK	GOOD			
INVERT	BRICK/CONCRETE	GOOD			

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SW	4' 3"	8	ACP	4	0	0			catch basin lead
IN FROM	SOUTH	4' 4"	8	VCP	1	0	0			bulkheaded @ 1'
IN FROM	MH8	6' 2"	48H85.5	BRK PIP		1.5	0			
IN FROM	MH10	5' 3"	12	VCP	2	0	4.5			overflow from manhole 4
OUT TO	NW 1	6' 5"	54	RCP	4	1	0			catch basin lead @ 4' @ 2:00 - 6" vcp
OUT TO	NW 2	6' 4"	54	RCP	4	1	0			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: CLARENDON AVENUE
Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLOUDY **Temp:** 38 **Time:**

Manhole No.: 10
Sub-System: NA
Common Manhole: ☐

COVER CHARACTERISTICS

Buried: ☐ CNL: ☐ CNI: ☐

Grade: BELOW
Amount: 1 In.

	QTY	SIZE (In)
Pick Hole(s)	1	2
Lift Hole(s)	0	0
Other Hole(s)	0	0

Cover & Adjacent Area Comments:

COVER INFLOW POTENTIAL

Drainage Area 1:

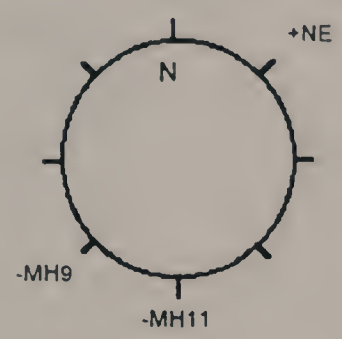
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: MH11

General Comments:
Storm drain manhole ; Sewage present - Photo #15.

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK/CONCRETE	FAIR			MISSING MORTAR
STEPS	BRICK	POOR			
WALLS	BRICK	GOOD			
FLOOR	BRICK	GOOD			
INVERT	BRICK	GOOD			

Surcharge From Invert: NONE EVIDENT **Currently:** Feet **Marks To:** Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	NE	4' 6"	12	VCP	2	.25	1.5			@ 3' 6" hole in pipe @ 3:00
OUT TO	MH9	4' 8"	15	VCP	2	0	4.5			@ 8' pipe bends left 15 degrees
OUT TO	MH11	4' 6"	8	VCP	2	.25	0			

Job Number: 99102

Utility Pipeline Services, Inc. Manhole Inspection Log

☐ Surface ☒ Internal

Municipality: CAMBRIDGE, MA
Street: CLARENDON AVENUE
Manhole No.: 11
Sub-System: NA
Common Manhole: ☐

Inspection Date: 01/10/2000 **Inspector:** GW **Map #:**
Weather: CLOUDY **Temp:** 38 **Time:**

COVER CHARACTERISTICS

Cover & Adjacent Area Comments:

Buried: ☐ CNL: ☐ CNI: ☐

Grade: AT
Amount: In.

	QTY	SIZE (In)
Pick Hole(s)	0	0
Lift Hole(s)	1	2
Other Hole(s)	0	0

COVER INFLOW POTENTIAL

Drainage Area 1:

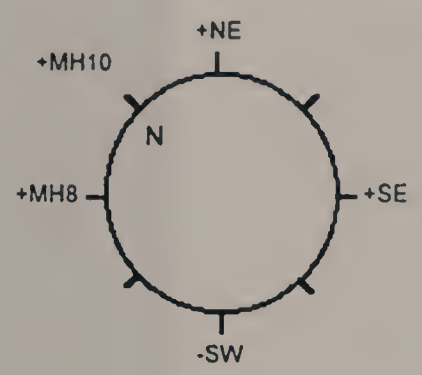
2 X 2 X 0.9 = 3.60 (SQFT)

Runoff Coefficient

Drainage Area 2: (if applicable)

X X 0.3 = (SQFT)

LINE ORIENTATION



Ft. to DS MH #: SW

General Comments:
Sanitary manhole ; Photo #16

Clear Opening Dia.: In.

INTERNAL MANHOLE OBSERVATIONS:

ITEM	MATERIAL	CONDITION	Leaks (gpm)	Photo	DEFECTS
FRAME	CAST	GOOD			
CORBEL	BRICK	FAIR			MISSING MORTAR; LOOSE BRICKS
STEPS	BRICK	POOR			
WALLS	BRICK	GOOD			
FLOOR	BRICK	FAIR			MISSING MORTAR
INVERT	BRICK	FAIR			MISSING MORTAR

Surcharge From Invert: NONE EVIDENT Currently: Feet Marks To: Feet

LINE CONDITIONS

Direction (In / Out)	Connect MH #	Rim To Invert (Ft. / In.)	Pipe Dia. (In.)	Pipe Material	Joint Length	Flow Depth (In.)	Debris Depth (In.)	Pipe Conn Leak (gpm)	Photo	Line Comments
IN FROM	SE	8' 1"	12	VCP	2	3.5	0			
IN FROM	NE	8' 3"	10	VCP	2	1	3			
IN FROM	MH8	7' 4"	10	CIP	4	1	0			@ 4' bends left 90 degrees; changes to 10" vcp
IN FROM	MH10	5' 4"	8	VCP	2	.125	0			poor pipe connection
OUT TO	SW	8' 3"	15	VCP	2	5	0			

Job Number: 99102

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #1
Manhole # CAM 401
Location: 140 Sherman Street
View of Weir Wall

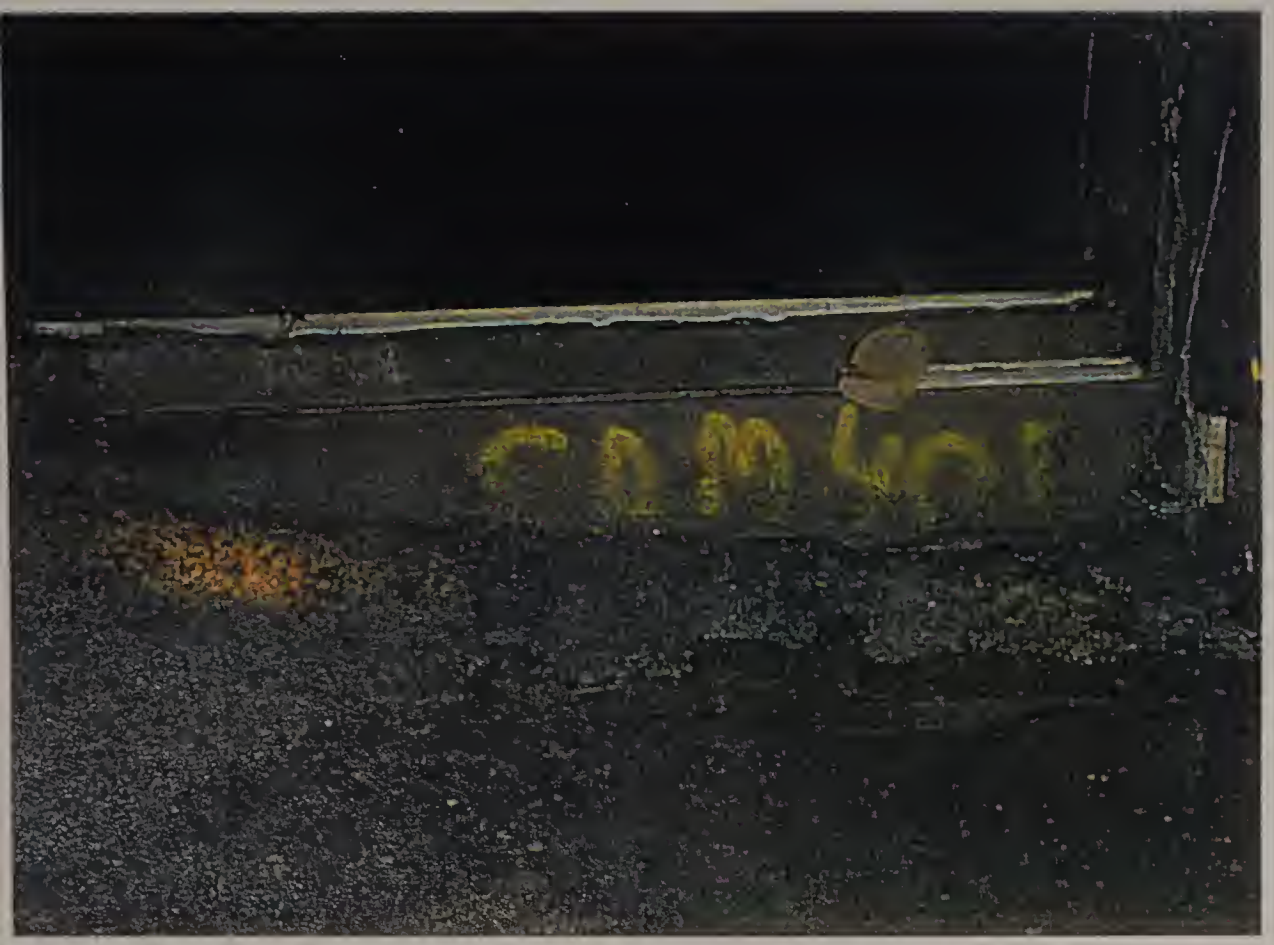


Photo #2
Manhole # CAM 401
140 Sherman Street
View of influent line from South

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #3
Manhole # CAM 401
140 Sherman Street
View of effluent line to North

Photo 4
Manhole #1
147 Pemberton Street
View of influent line from East

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #5
Manhole #2
Location: 147 Pemberton Street
View of Effluent line to South East

Photo #6
Manhole #3
Location: Pemberton Street @ Sherman Street
View of influent line from South

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #7
Manhole #3
Location: Pemberton Street @ Sherman Street
View of effluent line to the North

Photo #8
Manhole #4
Location: Pemberton Street @ Sherman Street
View of 64X72 concrete conduit entering @ 9:00

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #9
Manhole #4
Location: Pemberton Street @ Sherman Street
View of incoming 64X72 concrete conduit

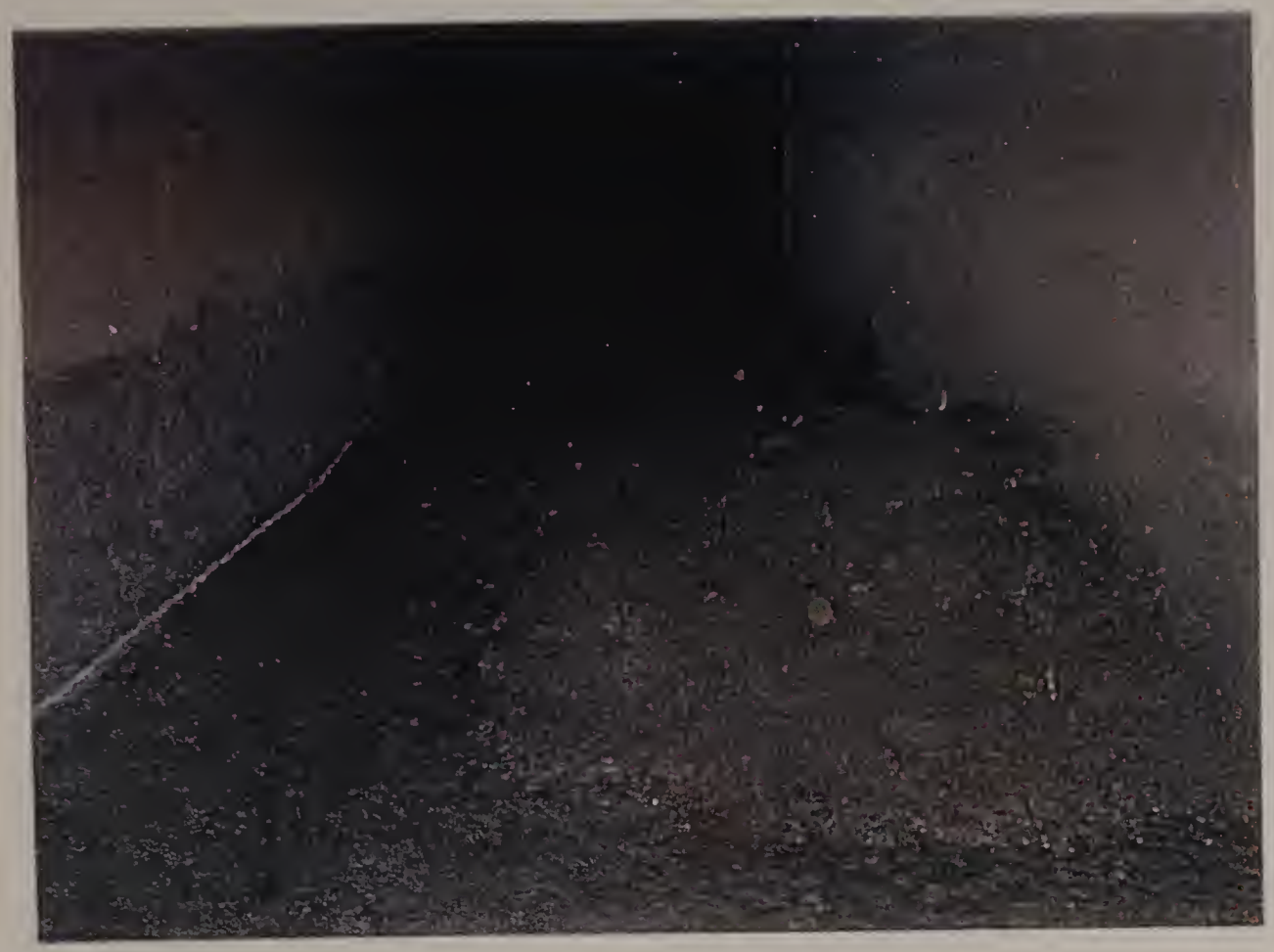


Photo 10
Manhole # 7
Location: Massachusetts Ave. @ Churchill Ave
View from top of Manhole

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #11
Manhole # 8
Location: Clarendon Avenue
View of influent line from South East

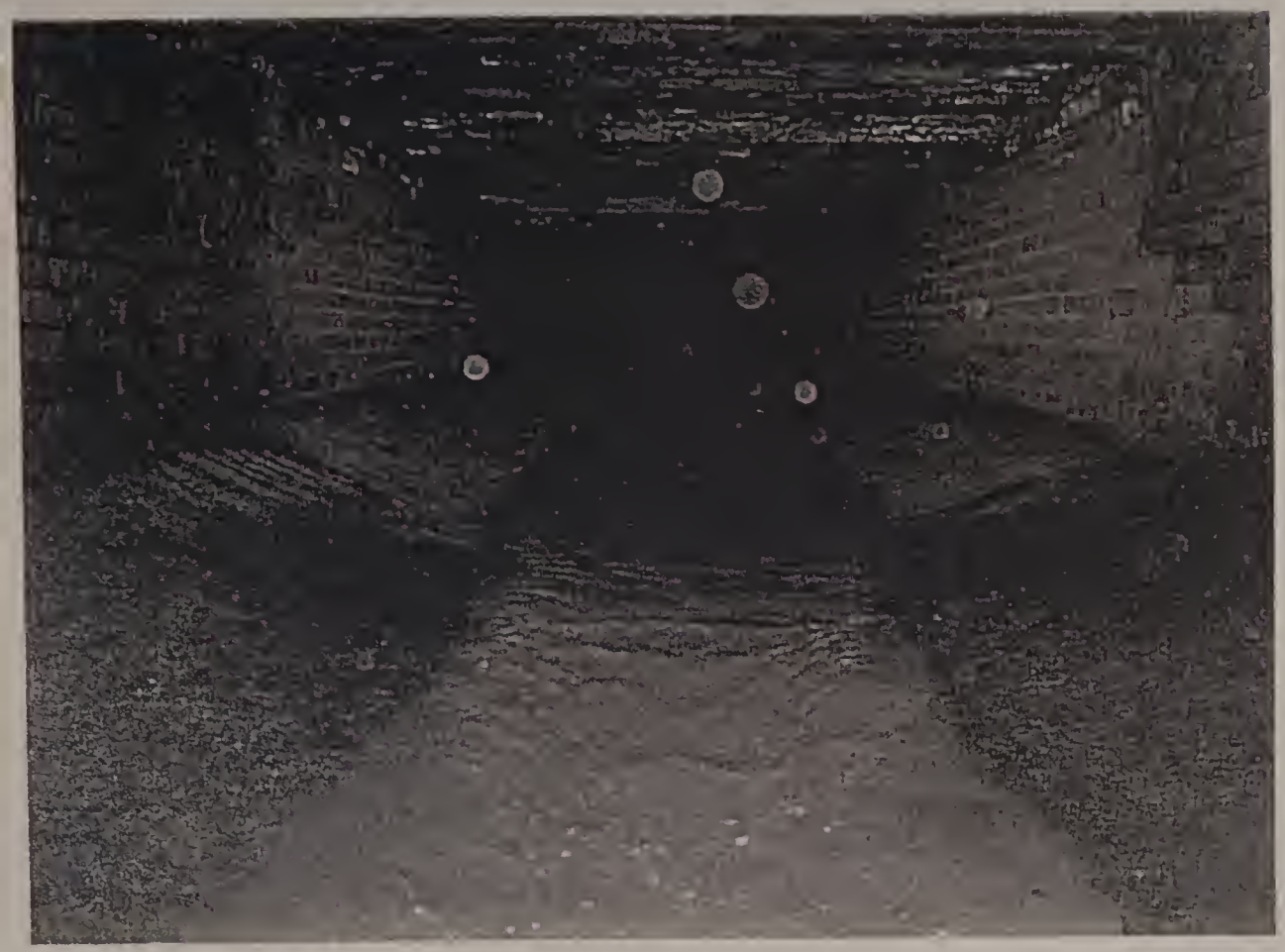


Photo #12
Manhole # 8
Location: Clarendon Avenue
View of effluent line to MH #9

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #13
Manhole # 9
Location: Clarendon Avenue
View of influent line

Photo #14
Manhole # 9
Location: Clarendon Avenue
View of effluent line

CAMBRIDGE, MA
MANHOLE INSPECTION PHOTOS

Photo #15
Manhole # 10
Location: Clarendon Avenue
Sewage noted in Storm Manhole

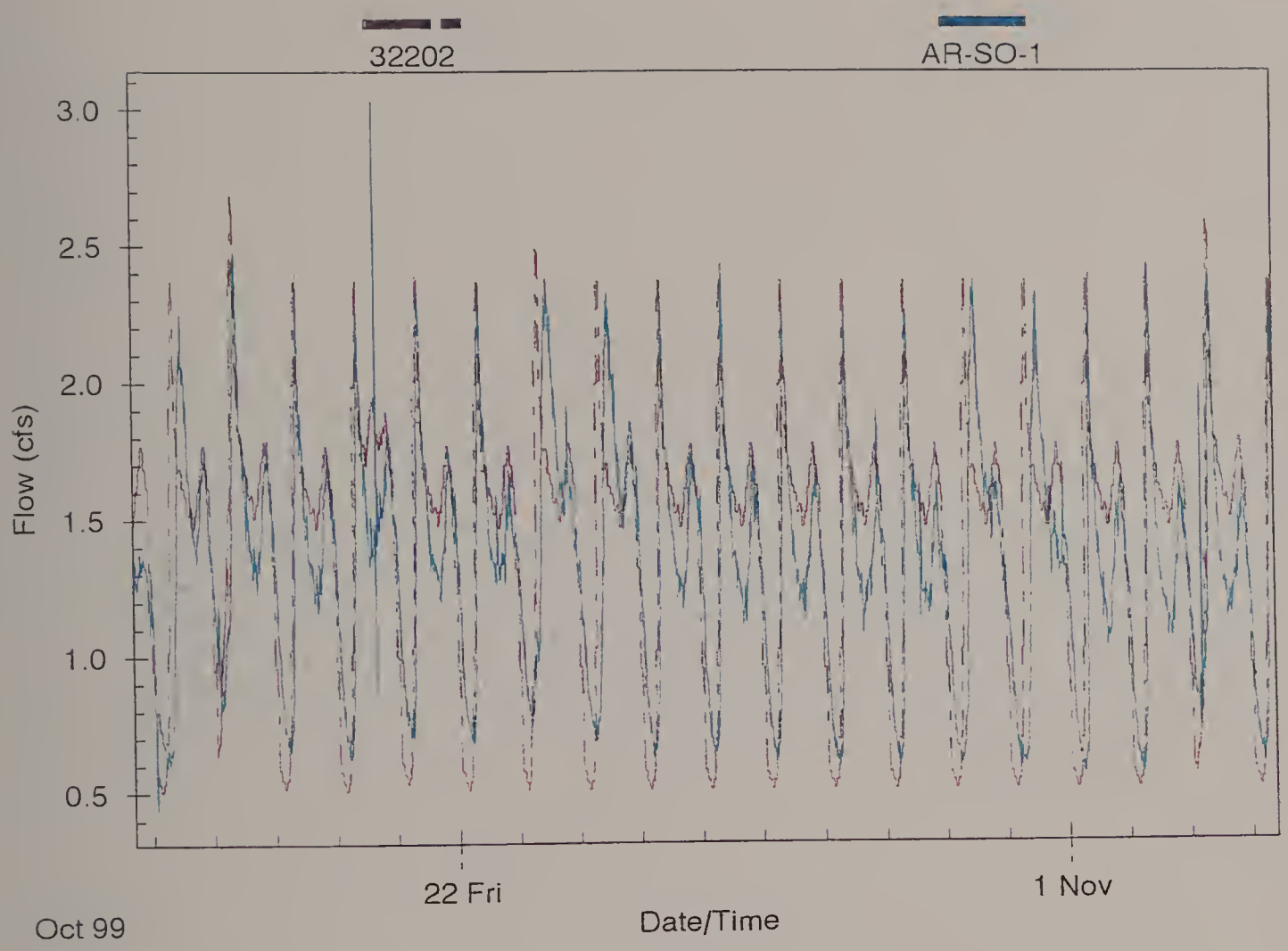
Photo #16
Manhole # 11
Location: Clarendon Avenue
Sanitary Manhole

Appendix D

Appendix D

APPENDIX D

SWMM CALIBRATION PLOTS



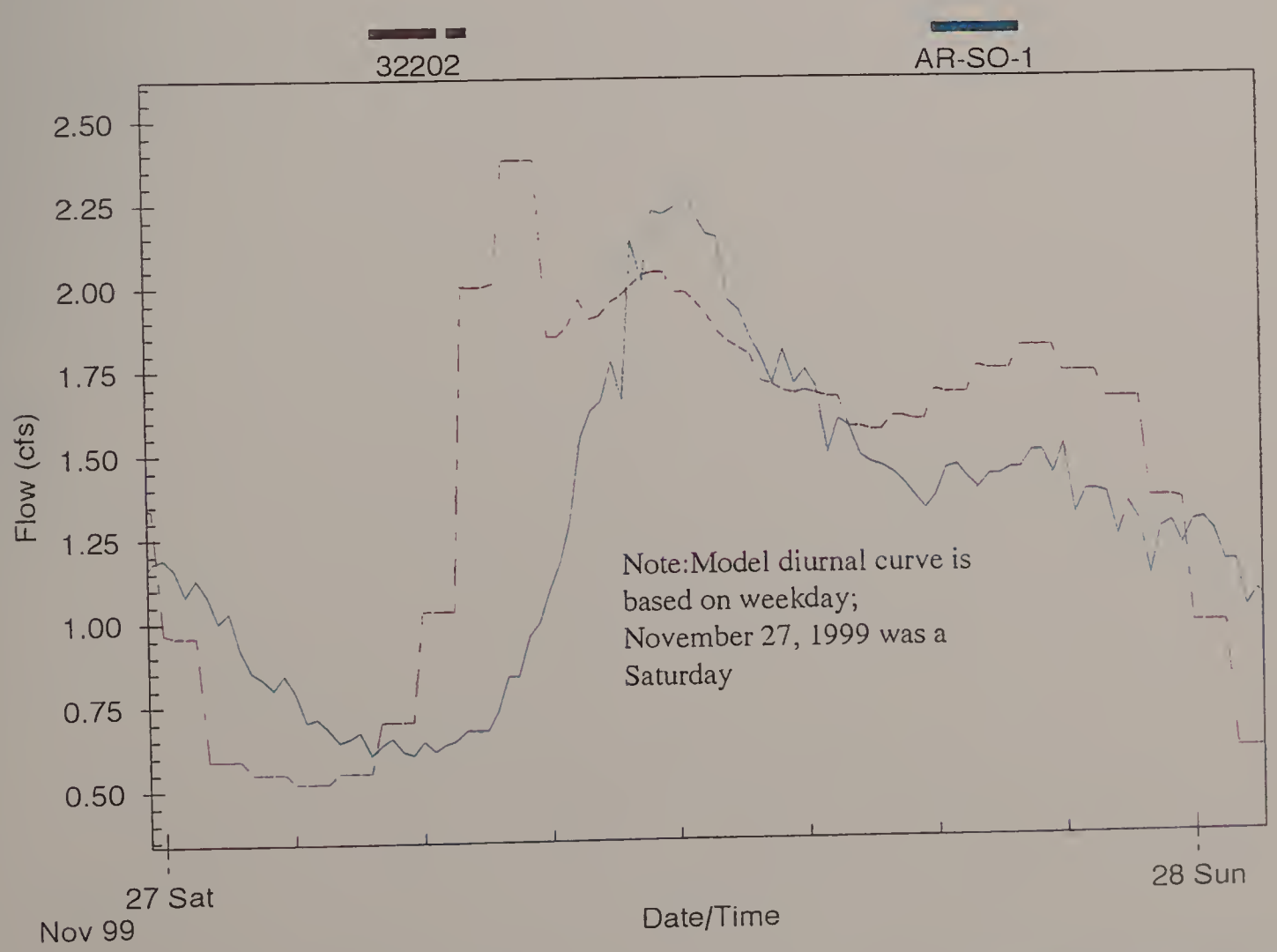
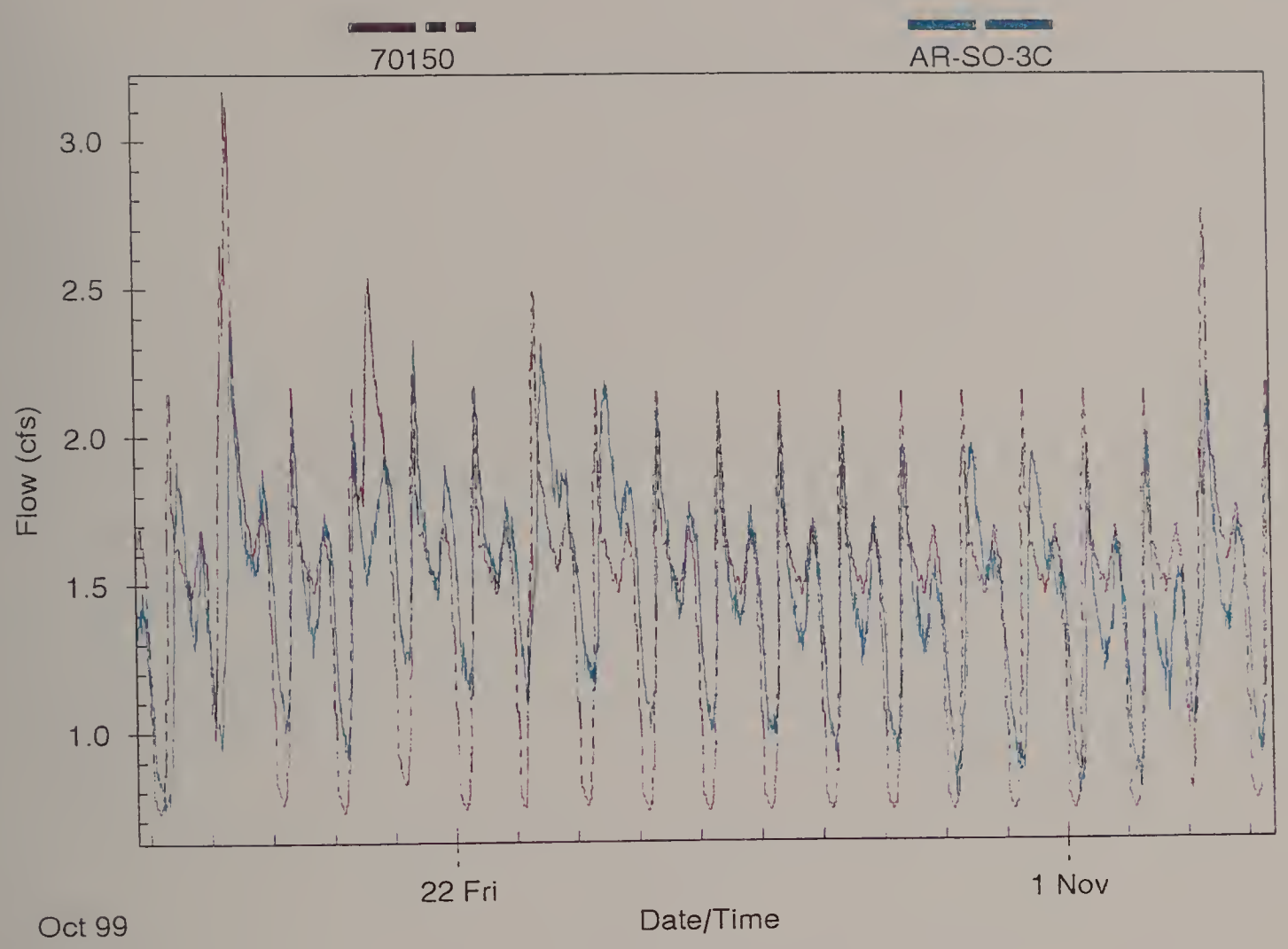


FIGURE C-1. COMPARISON OF MEASURED AND SIMULATED FLOW METER AR-SO-1



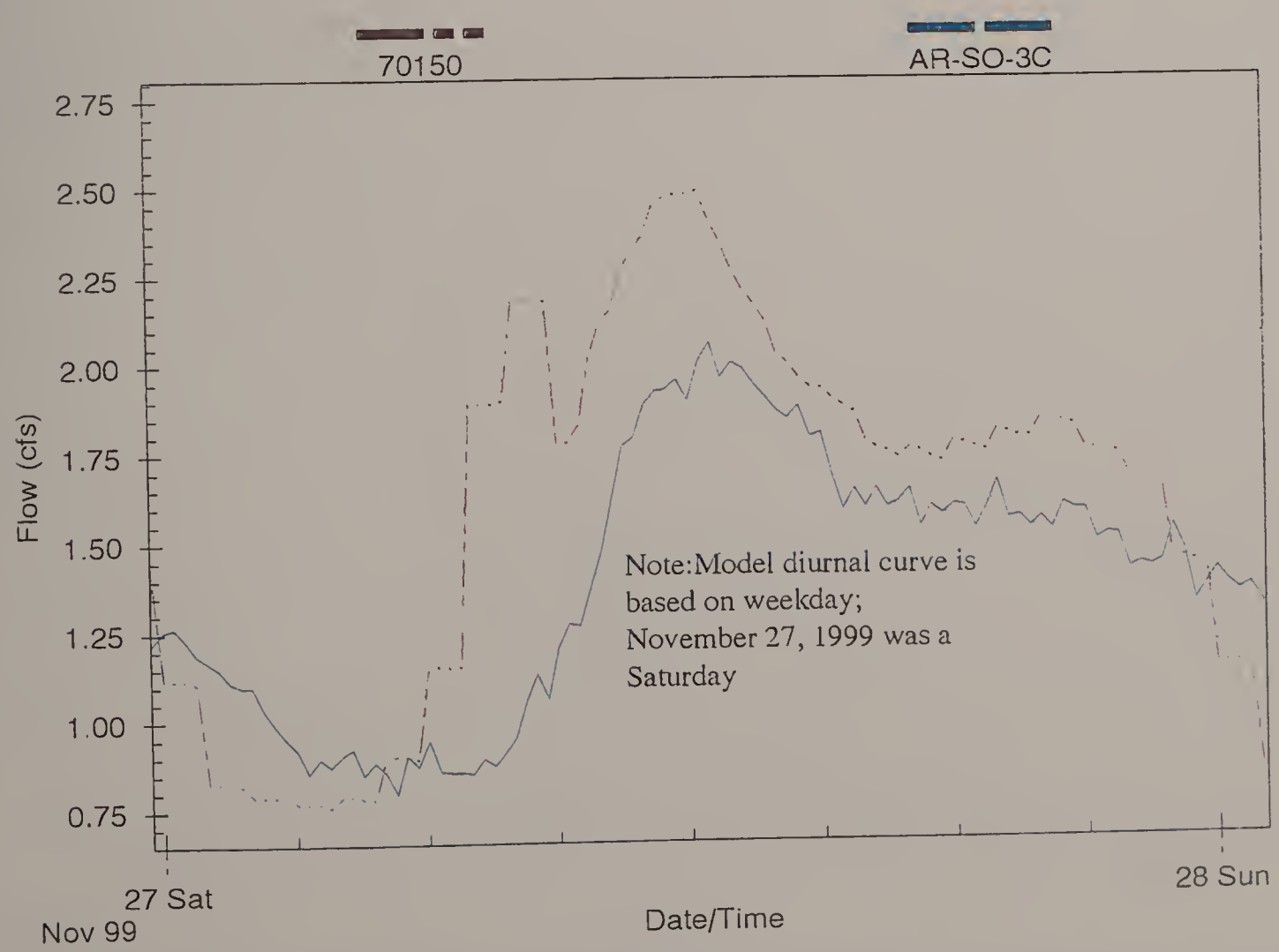
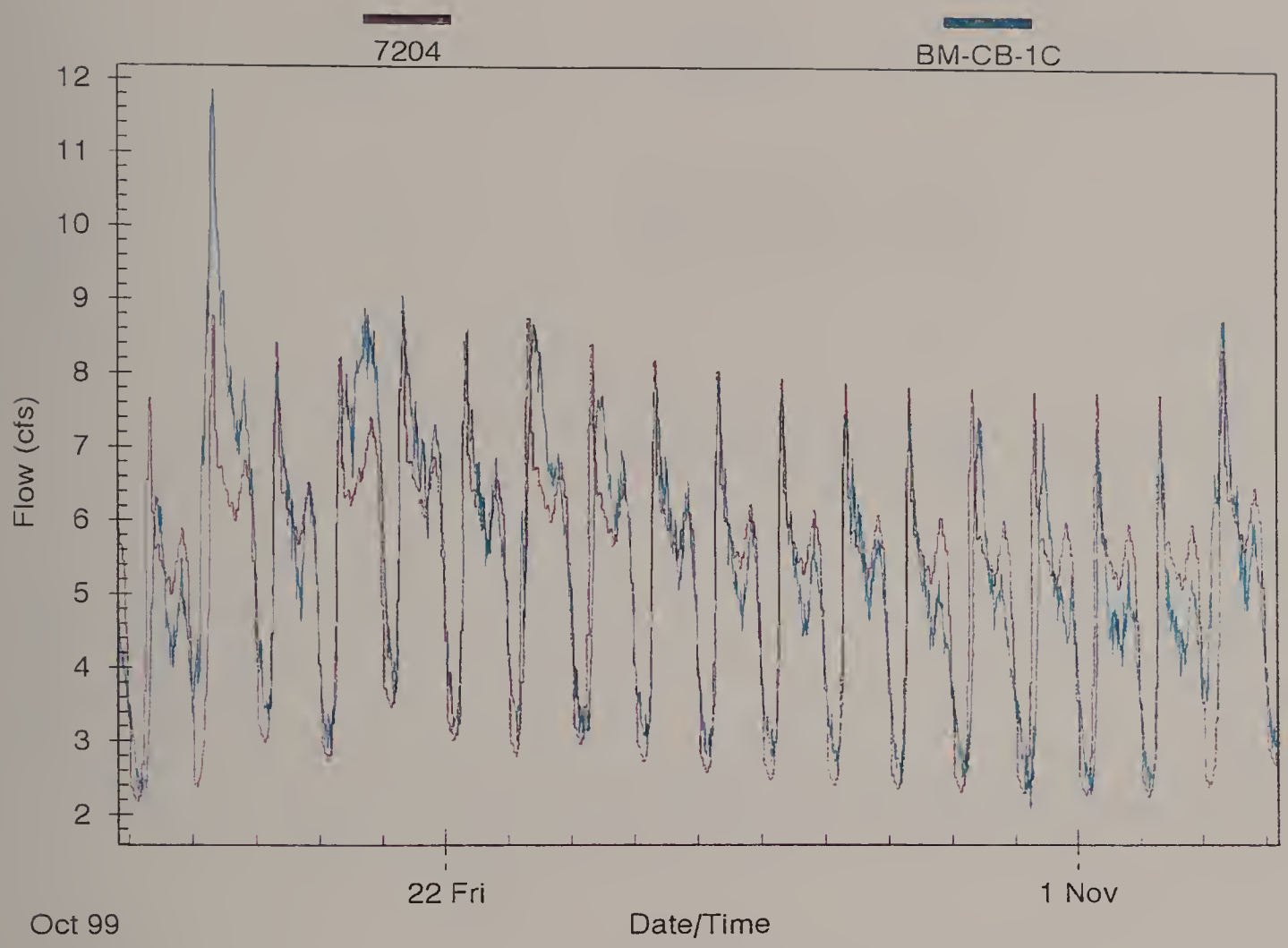


FIGURE C-2. COMPARISON OF MEASURED AND SIMULATED FLOW METER AR-SO-3C



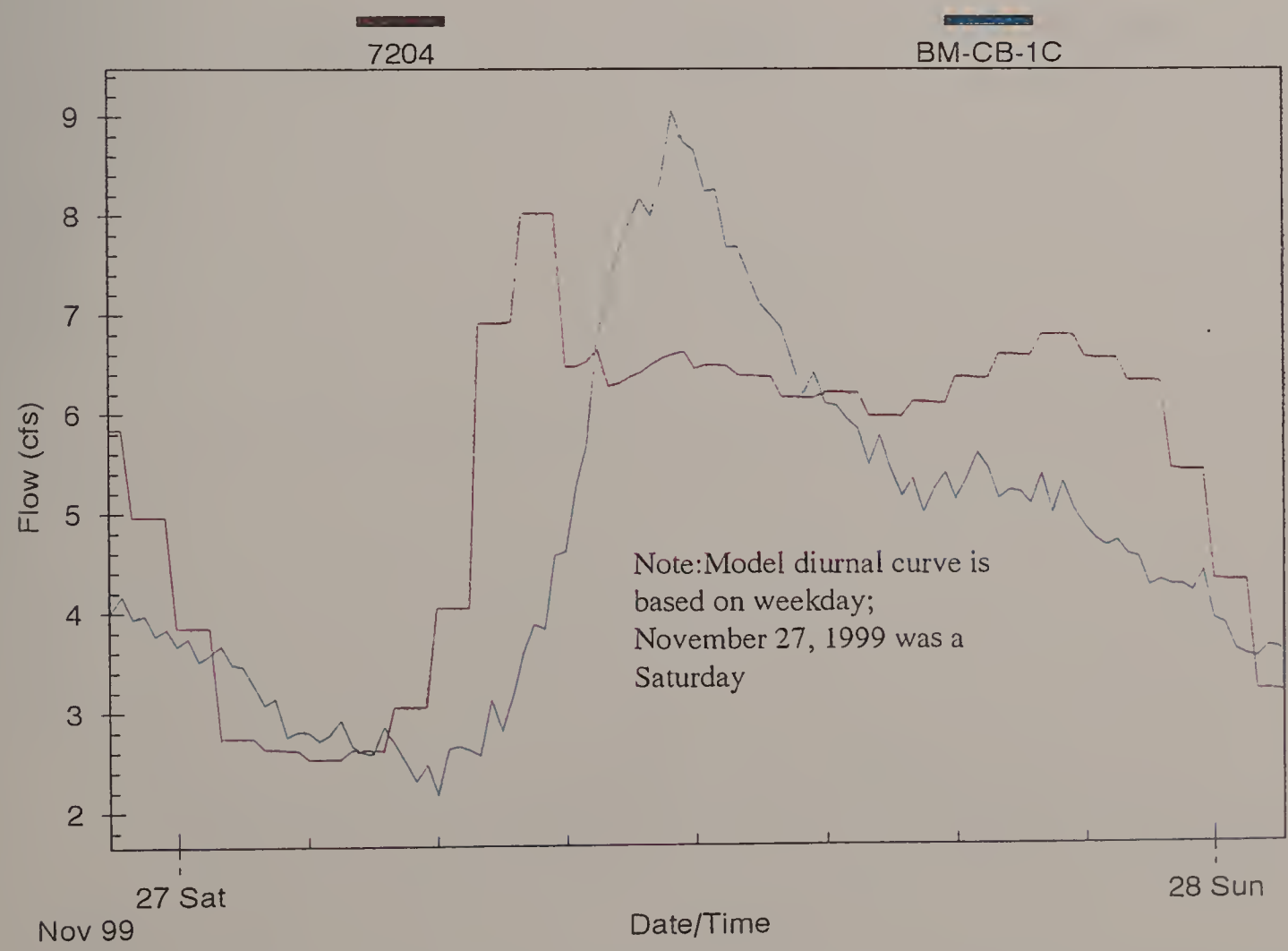
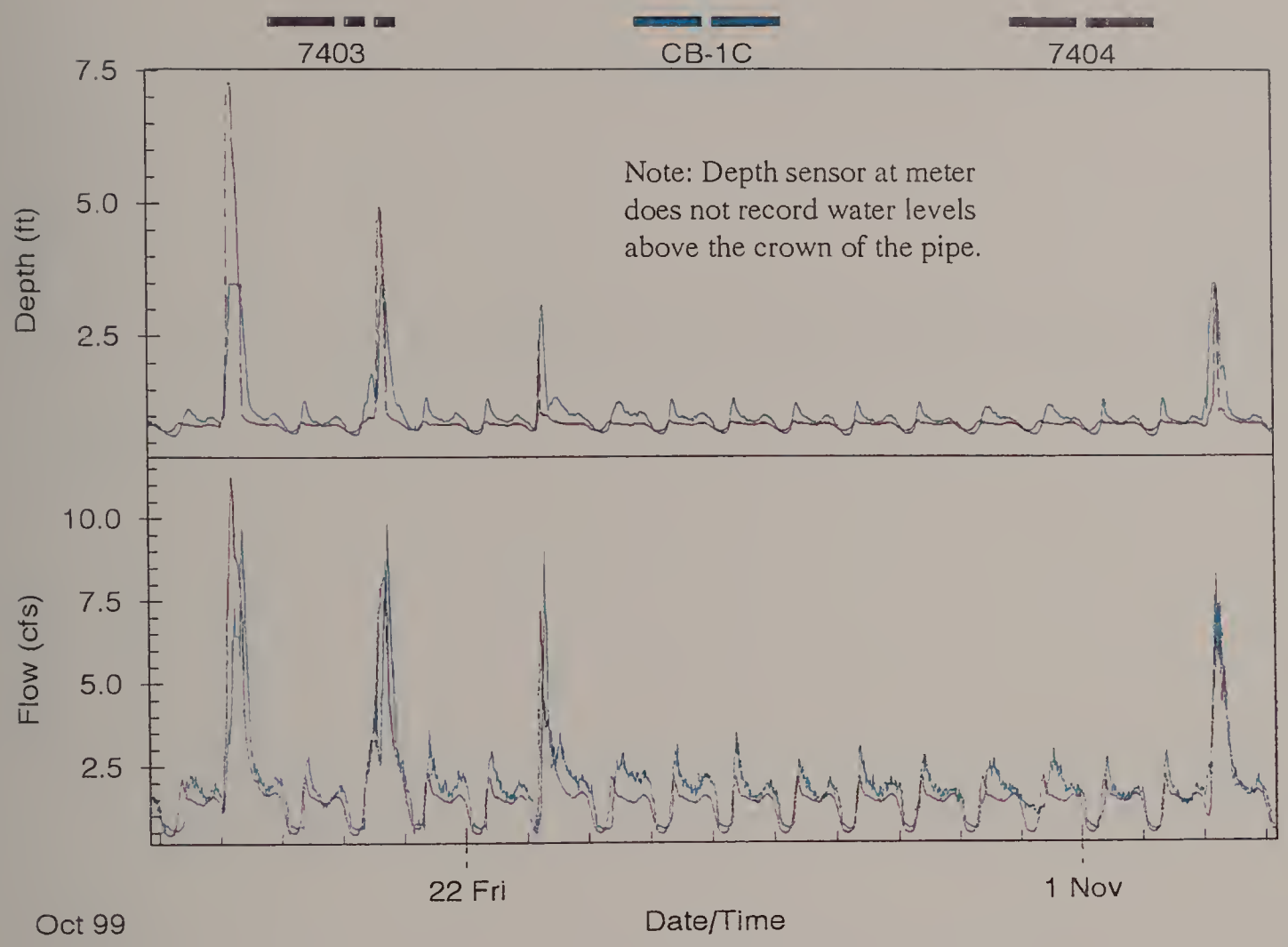


FIGURE C-3. COMPARISON OF MEASURED AND SIMULATED FLOW METER BM-CB-1C



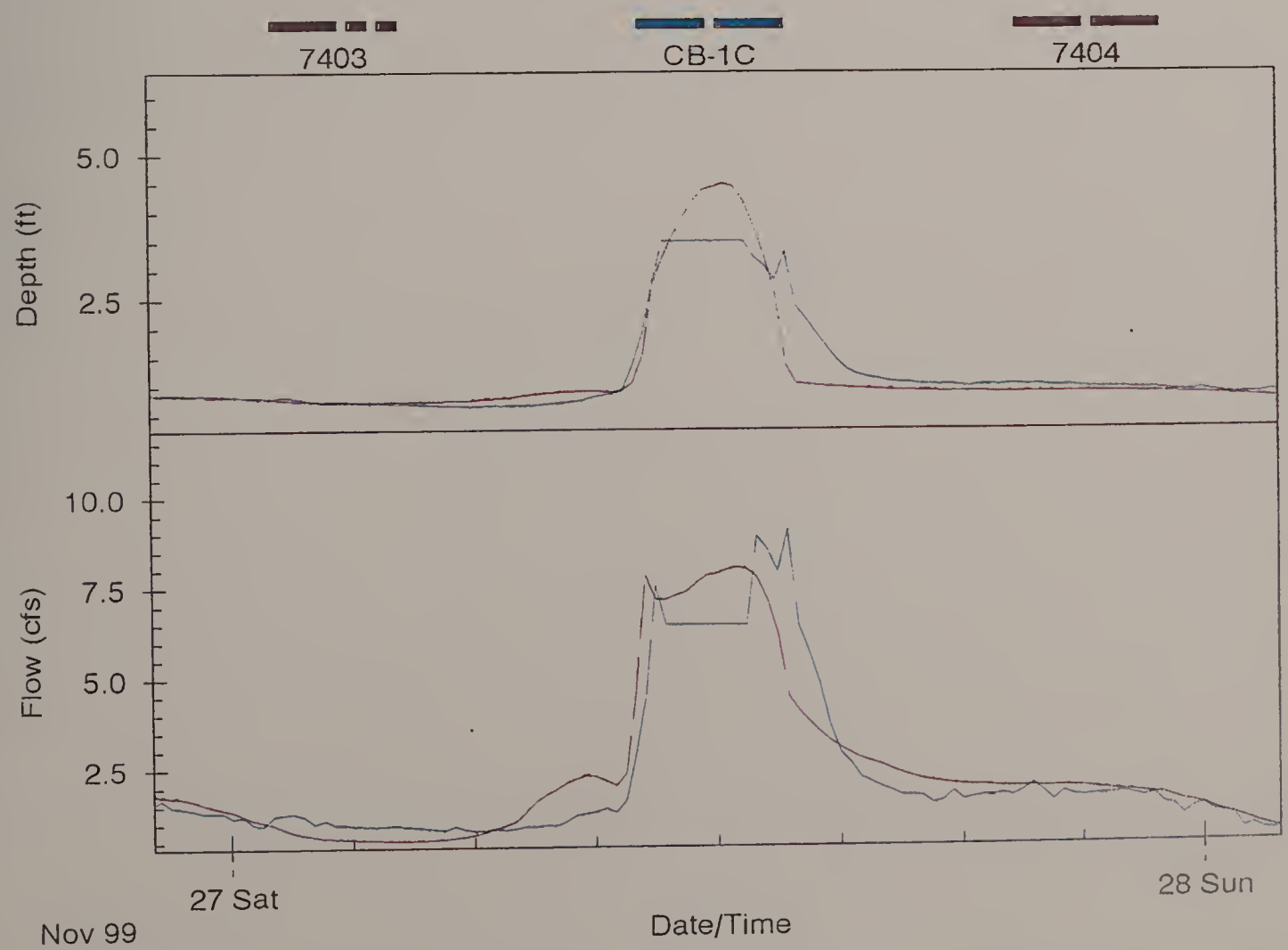


FIGURE C-4. COMPARISON OF MEASURED AND SIMULATED FLOW METER CB-1C

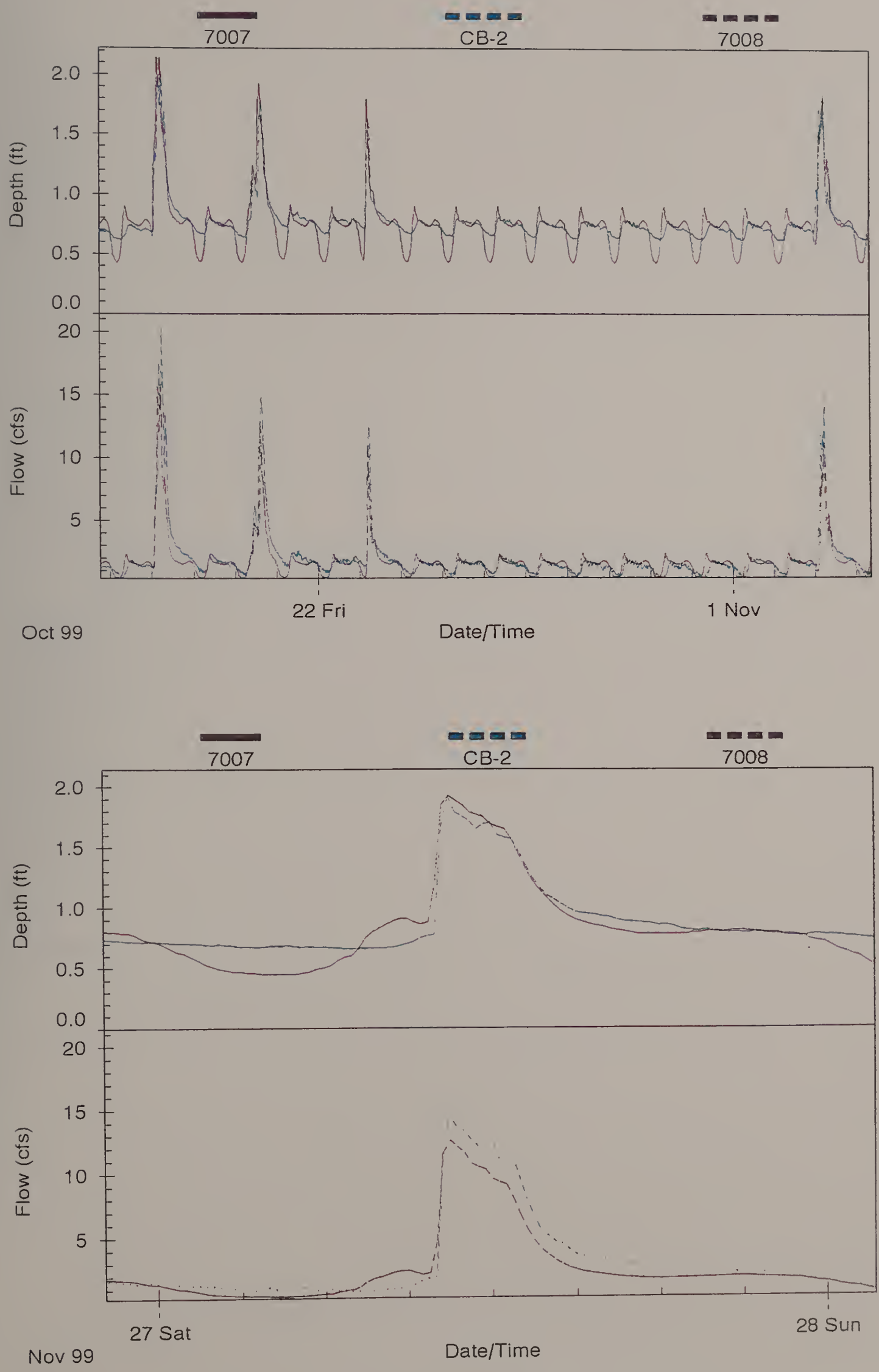
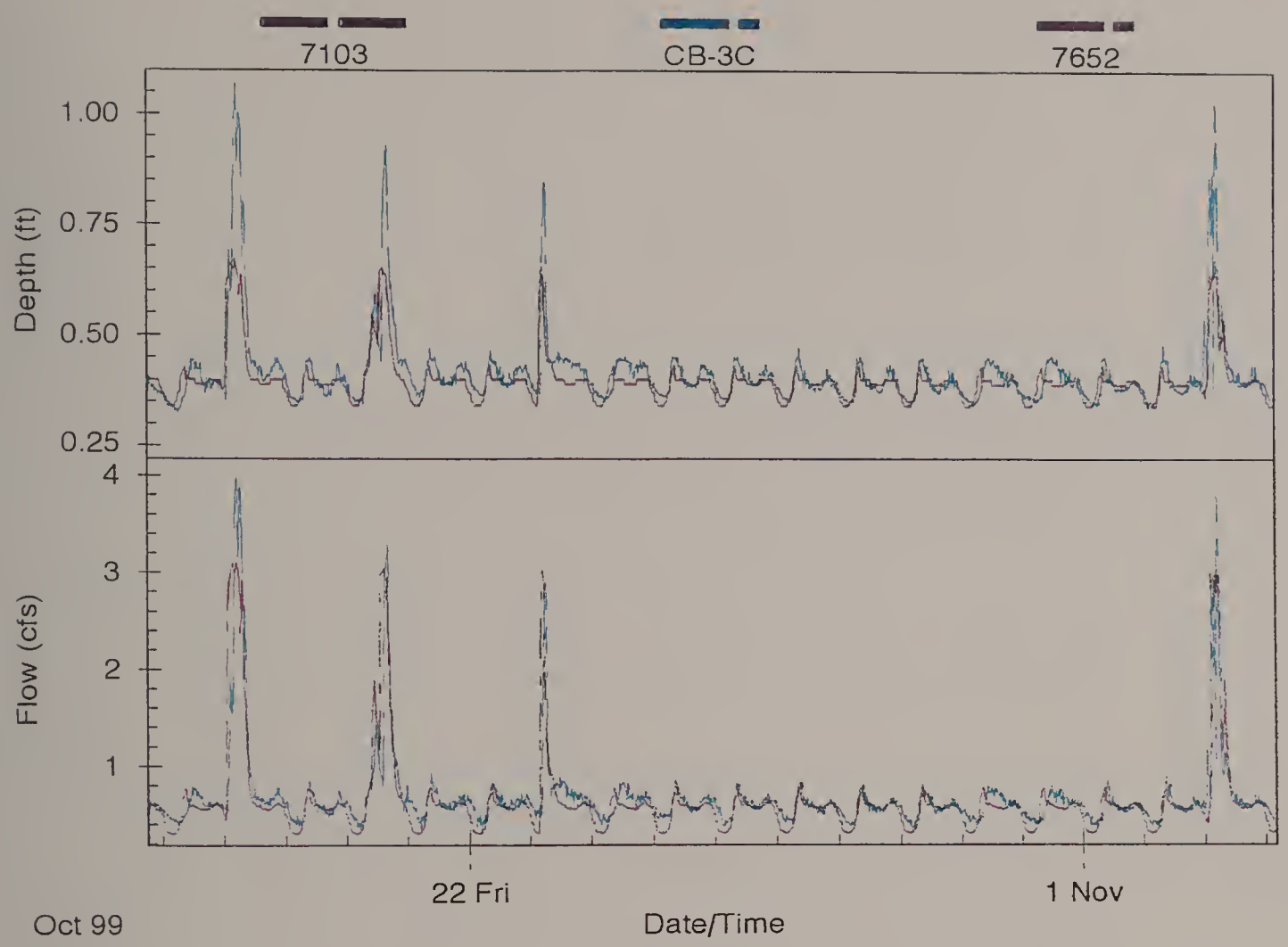


FIGURE C-5. COMPARISON OF MEASURED AND SIMULATED FLOW METER CB-2



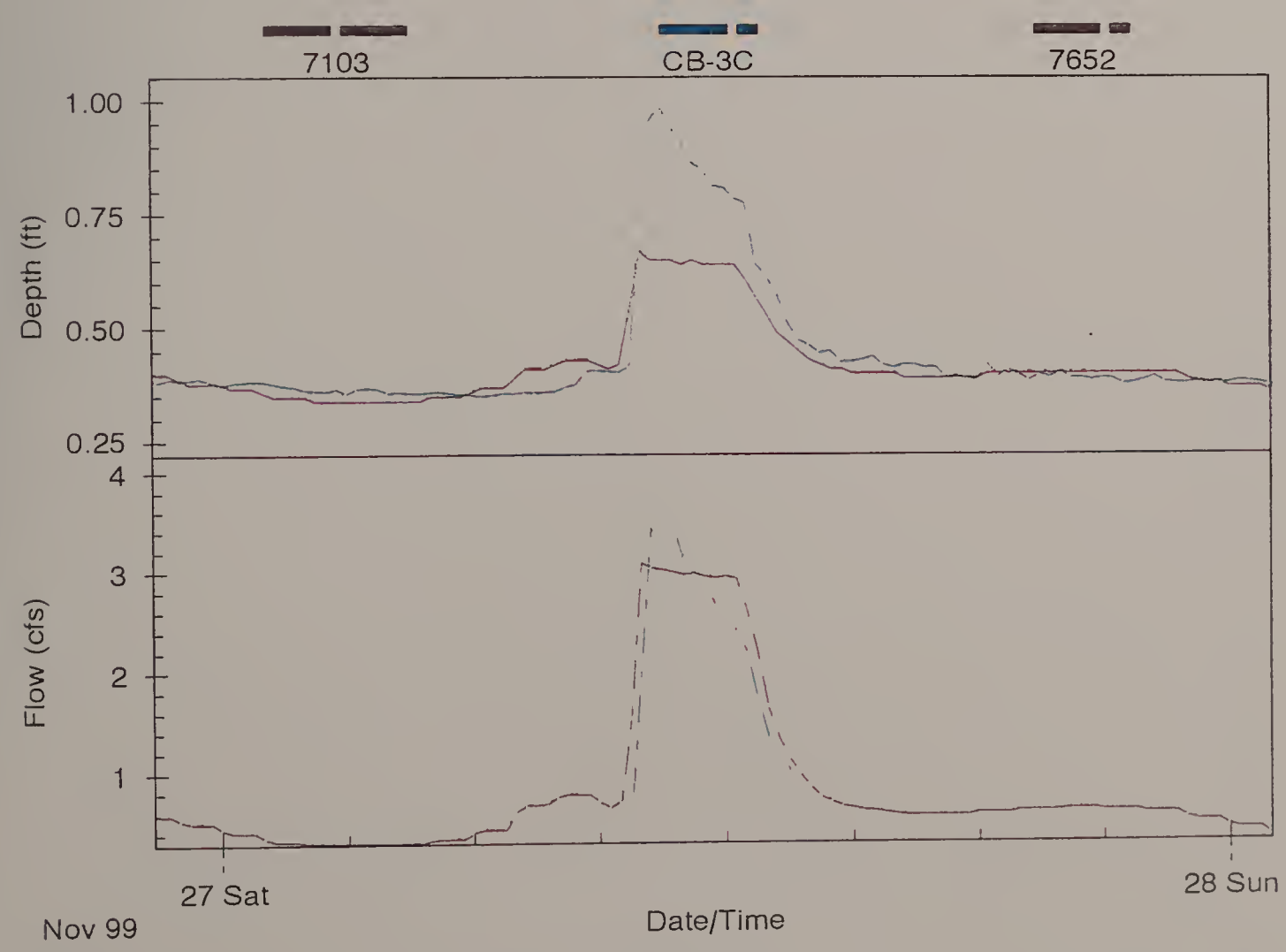
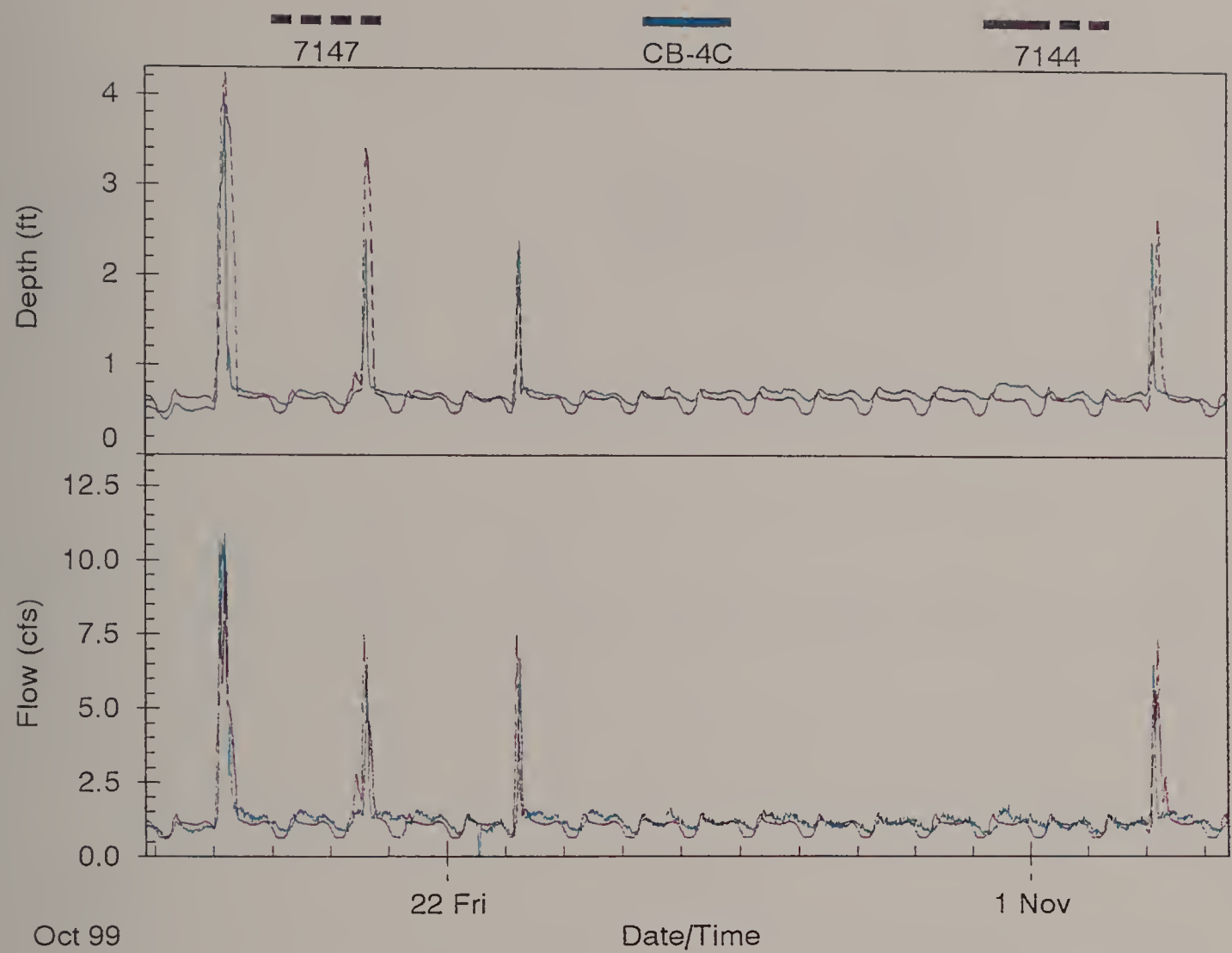


FIGURE C-6. COMPARISON OF MEASURED AND SIMULATED FLOW METER CB-3C



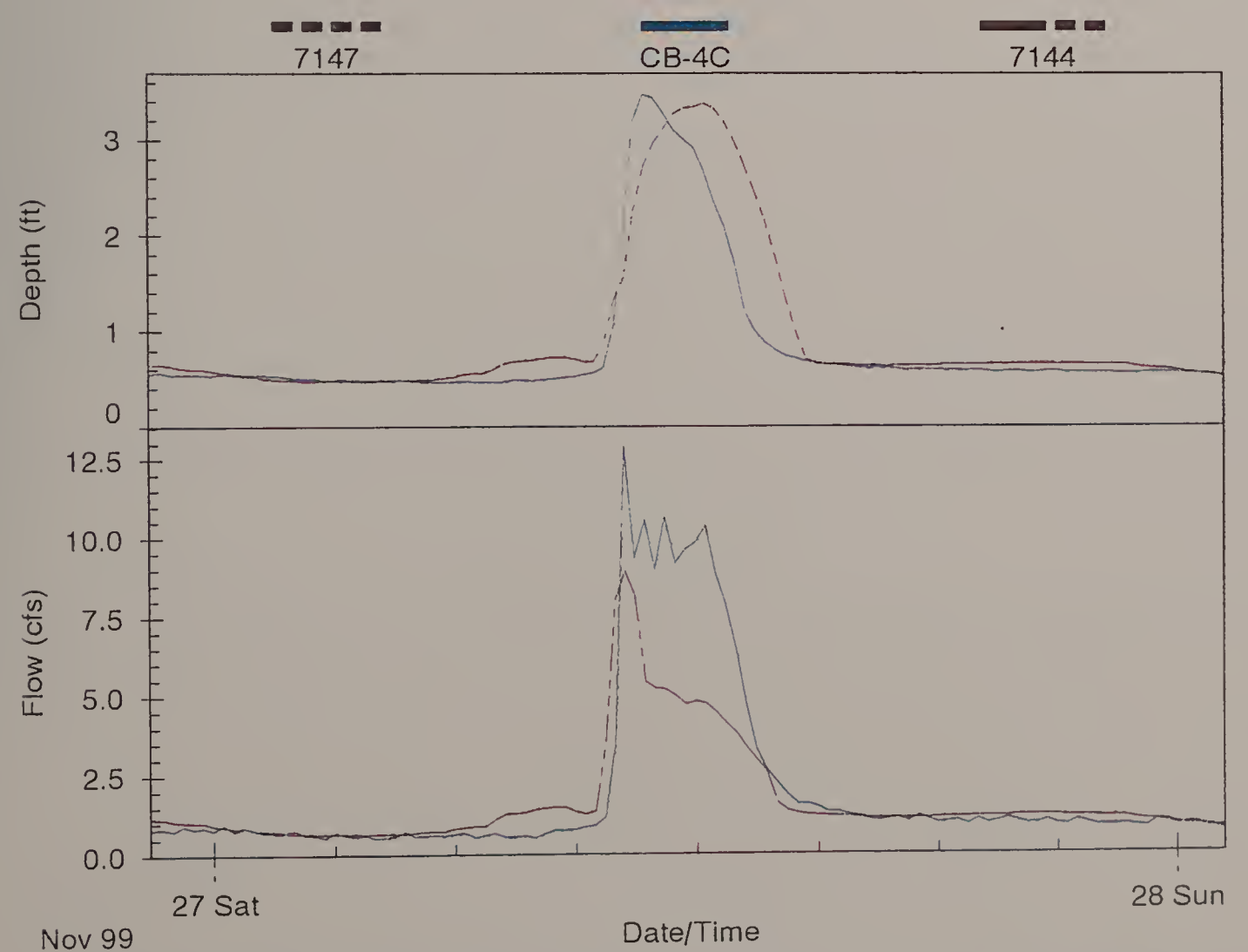
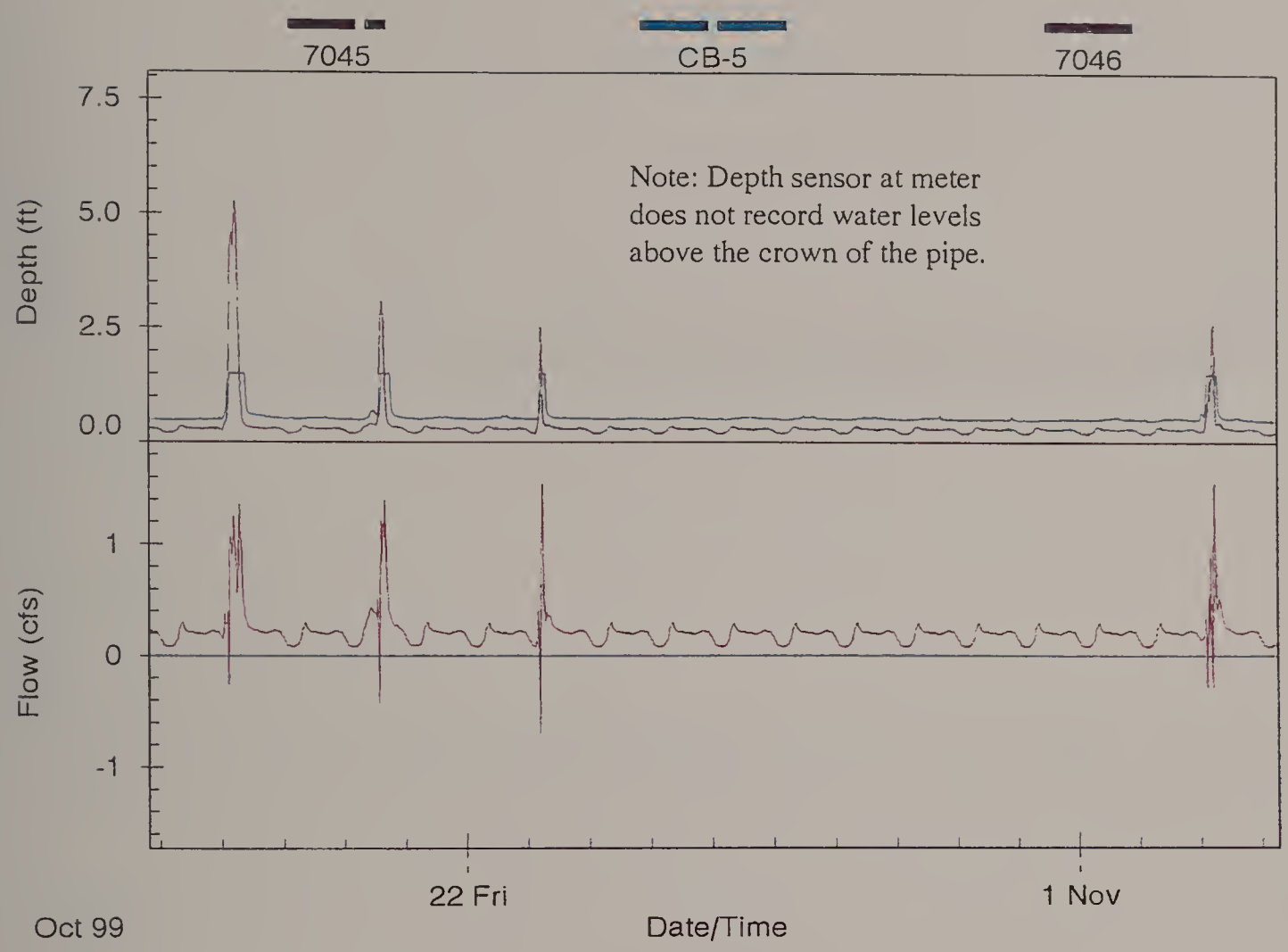


FIGURE C-7. COMPARISON OF MEASURED AND SIMULATED FLOW METER CB-4C



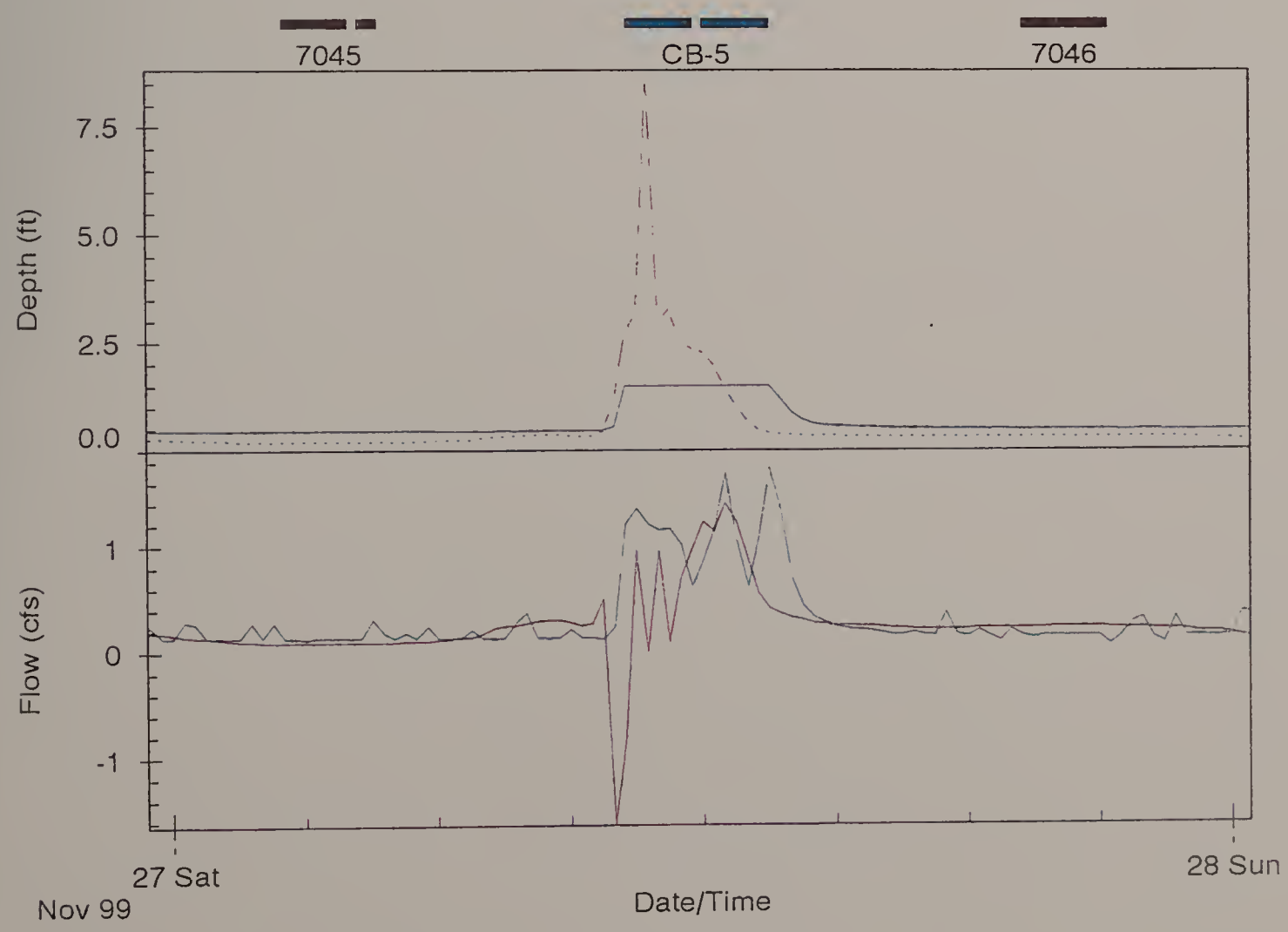


FIGURE C-8. COMPARISON OF MEASURED AND SIMULATED FLOW METER CB-5

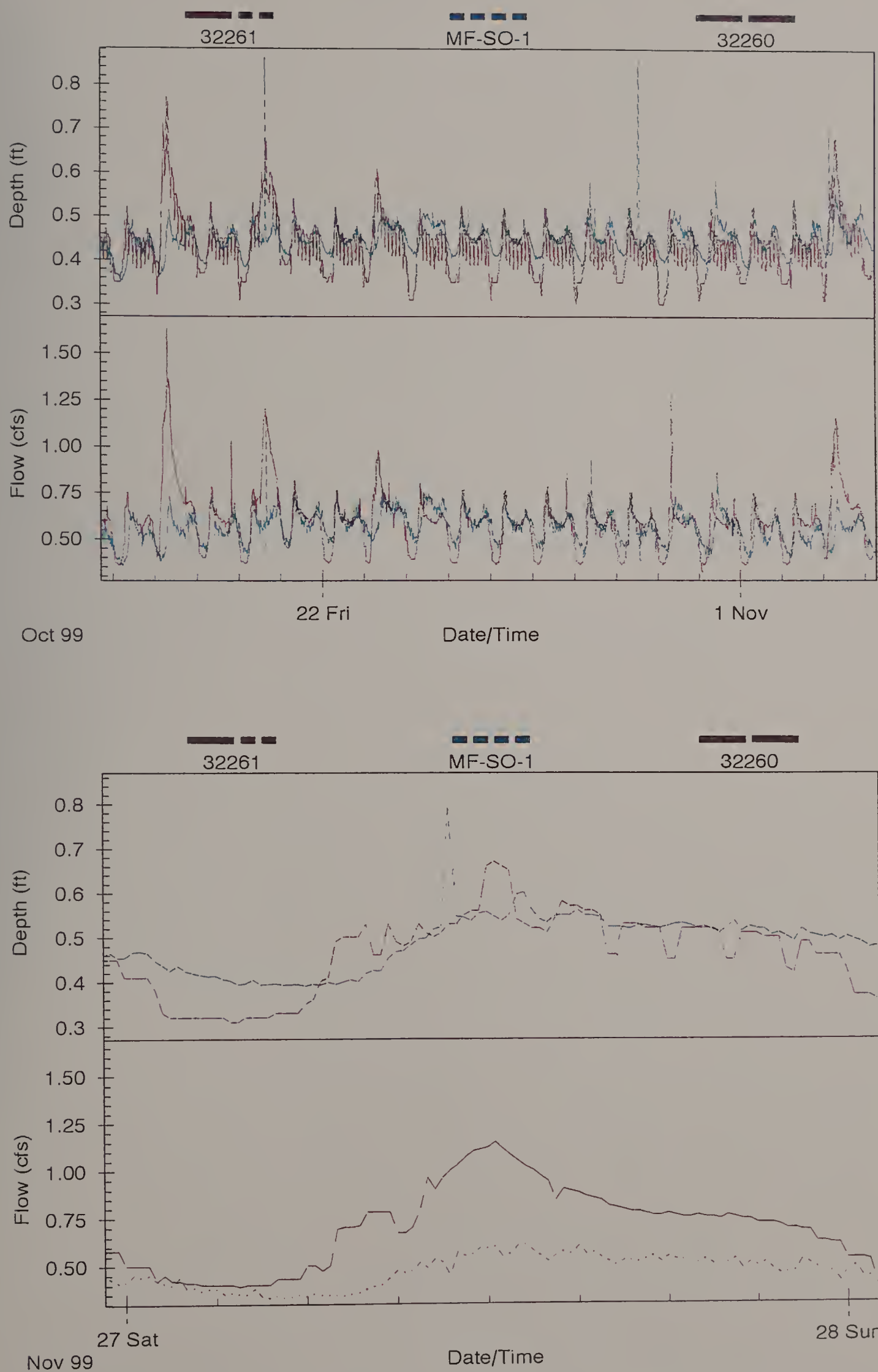
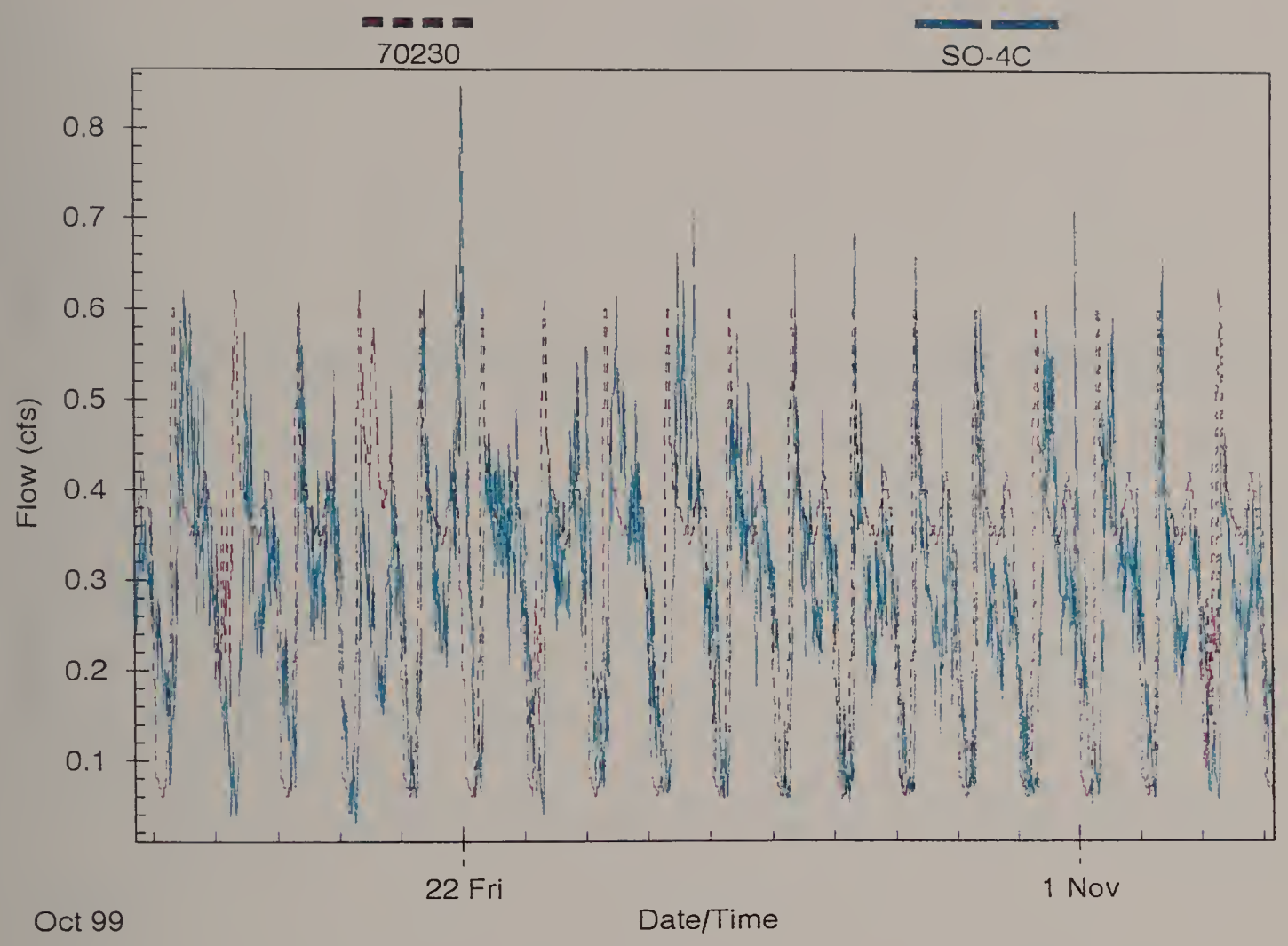


FIGURE C-9. COMPARISON OF MEASURED AND SIMULATED FLOW METER MF-SO-1



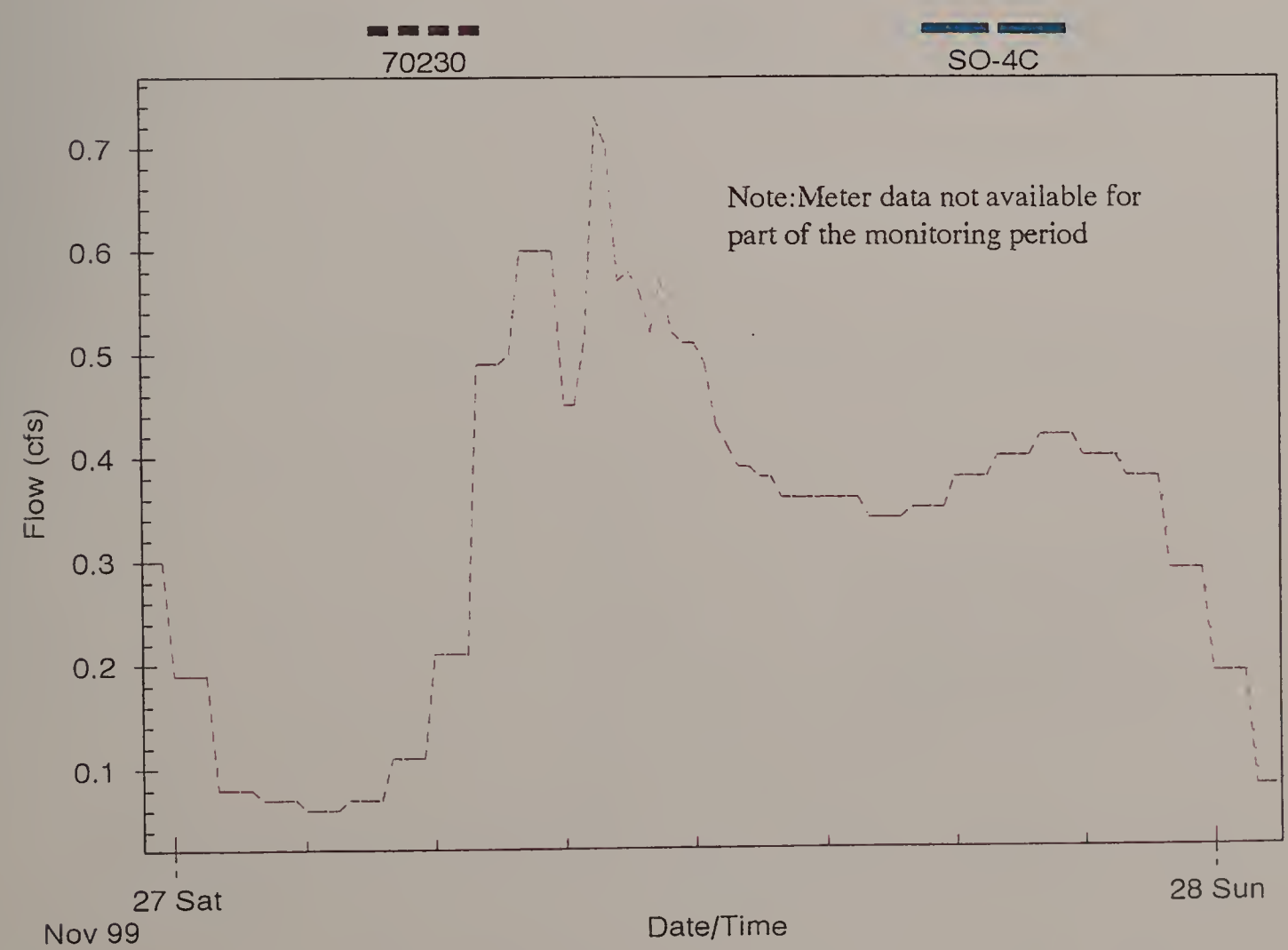
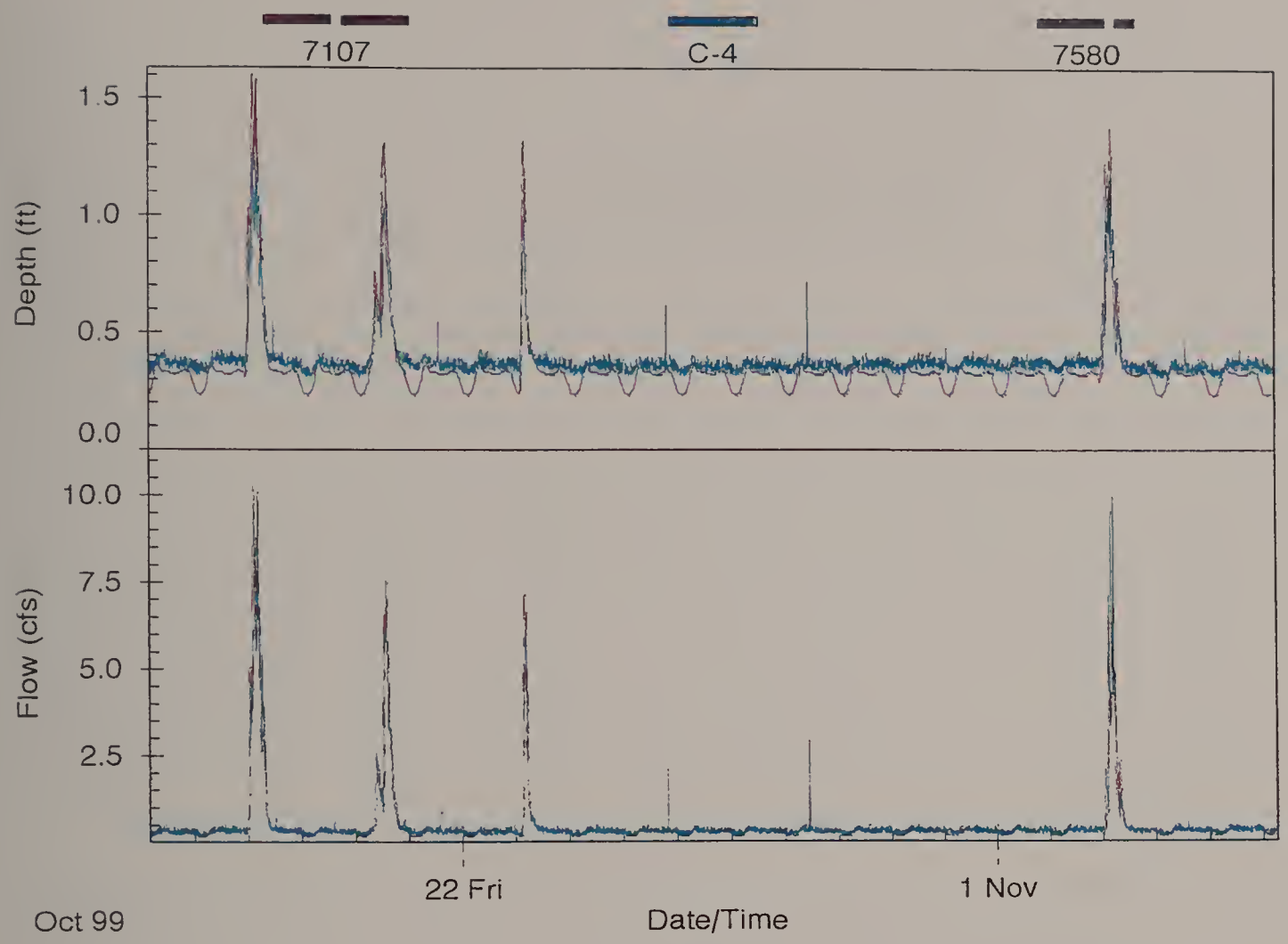


FIGURE C-10. COMPARISON OF MEASURED AND SIMULATED FLOW METER SO-4C



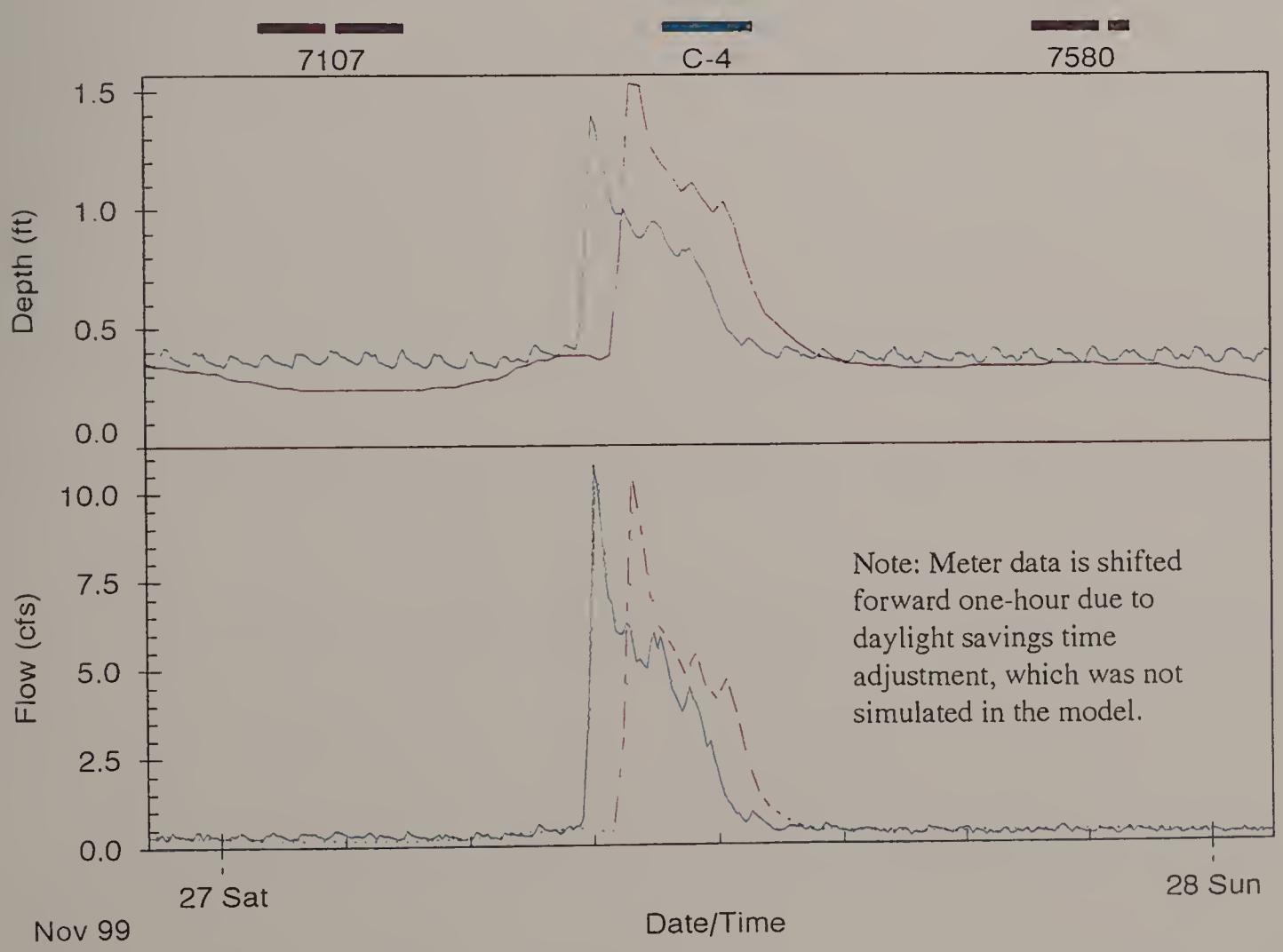
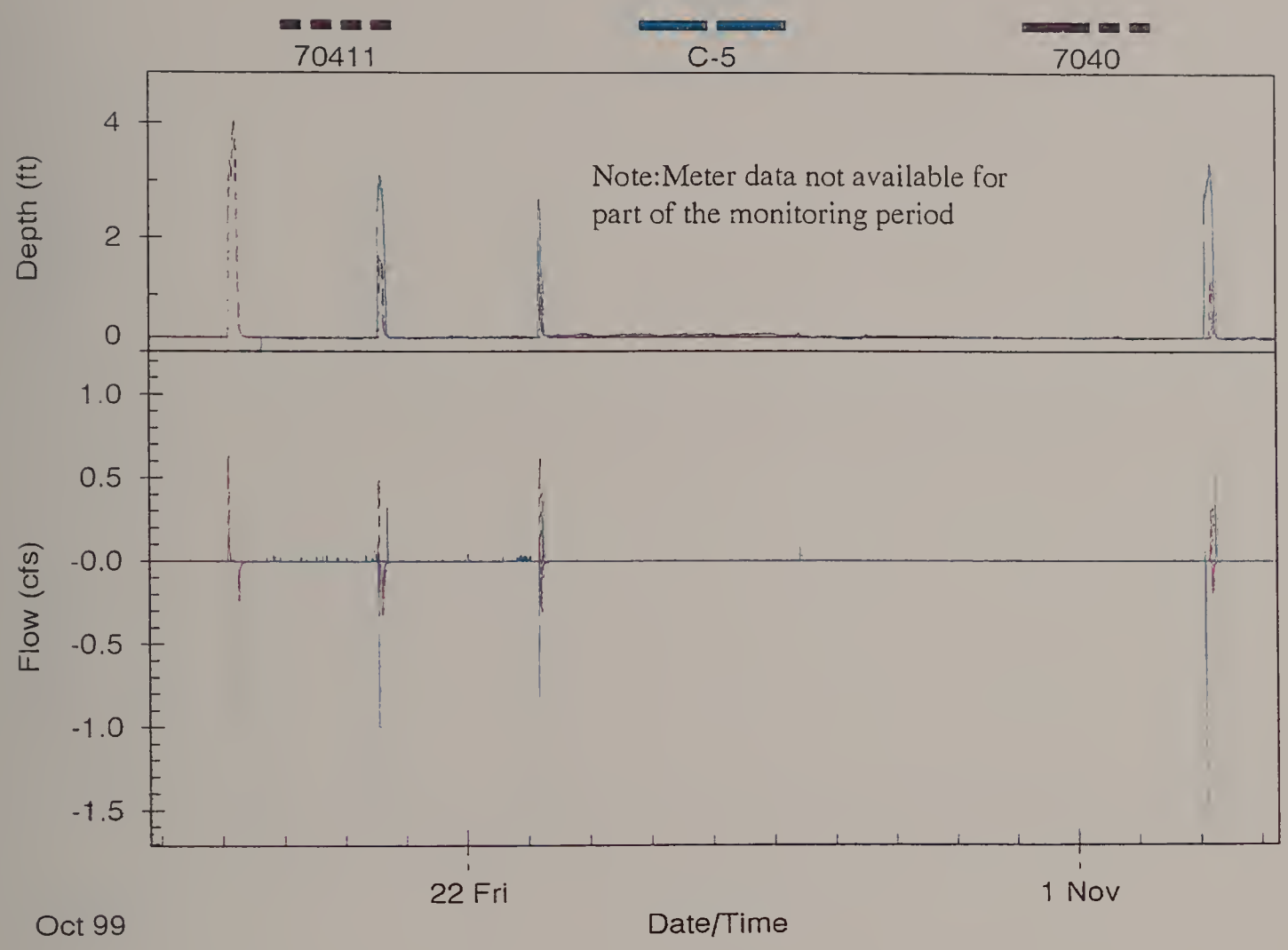


FIGURE C-11. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-4



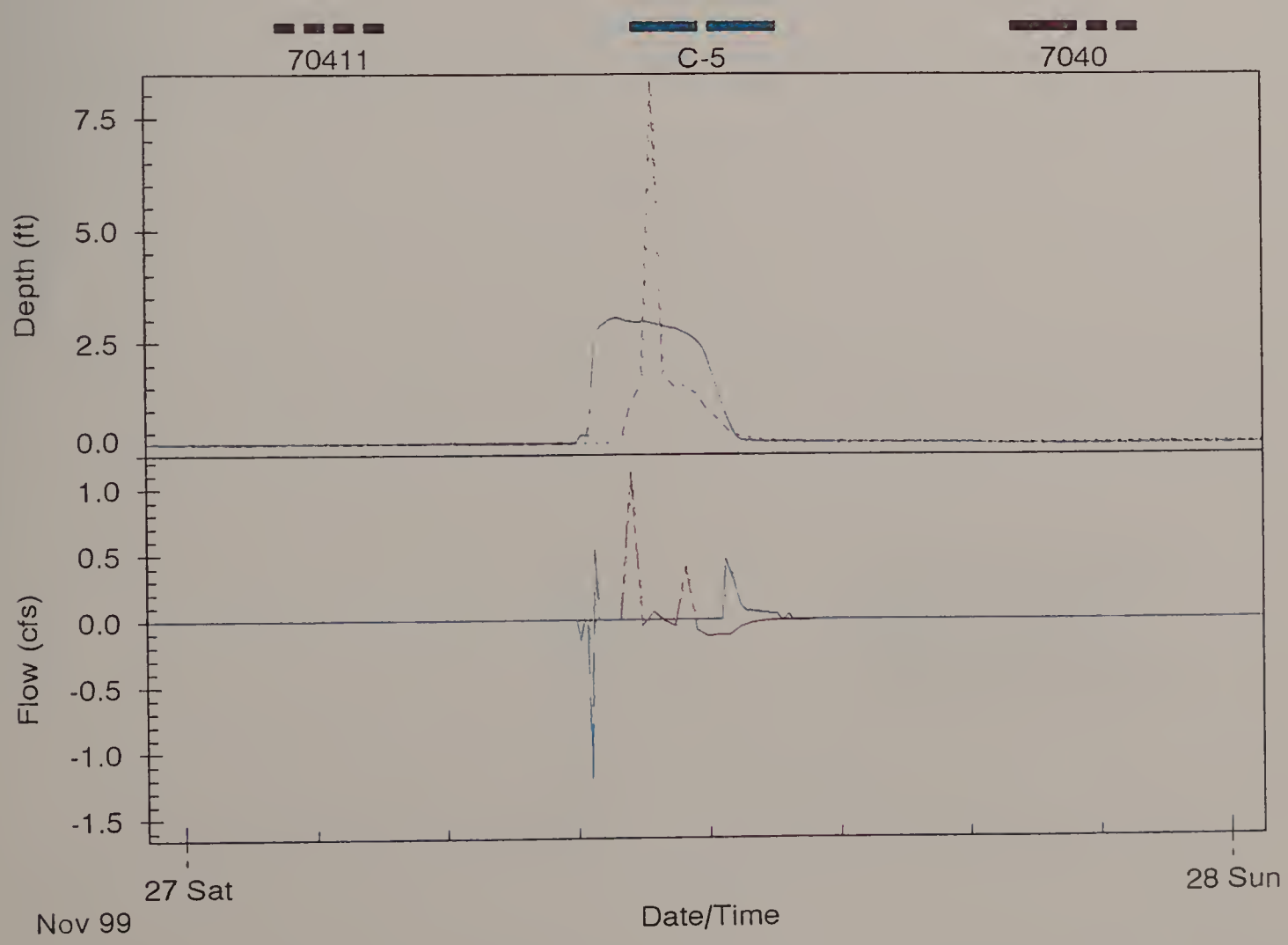


FIGURE C-12. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-5

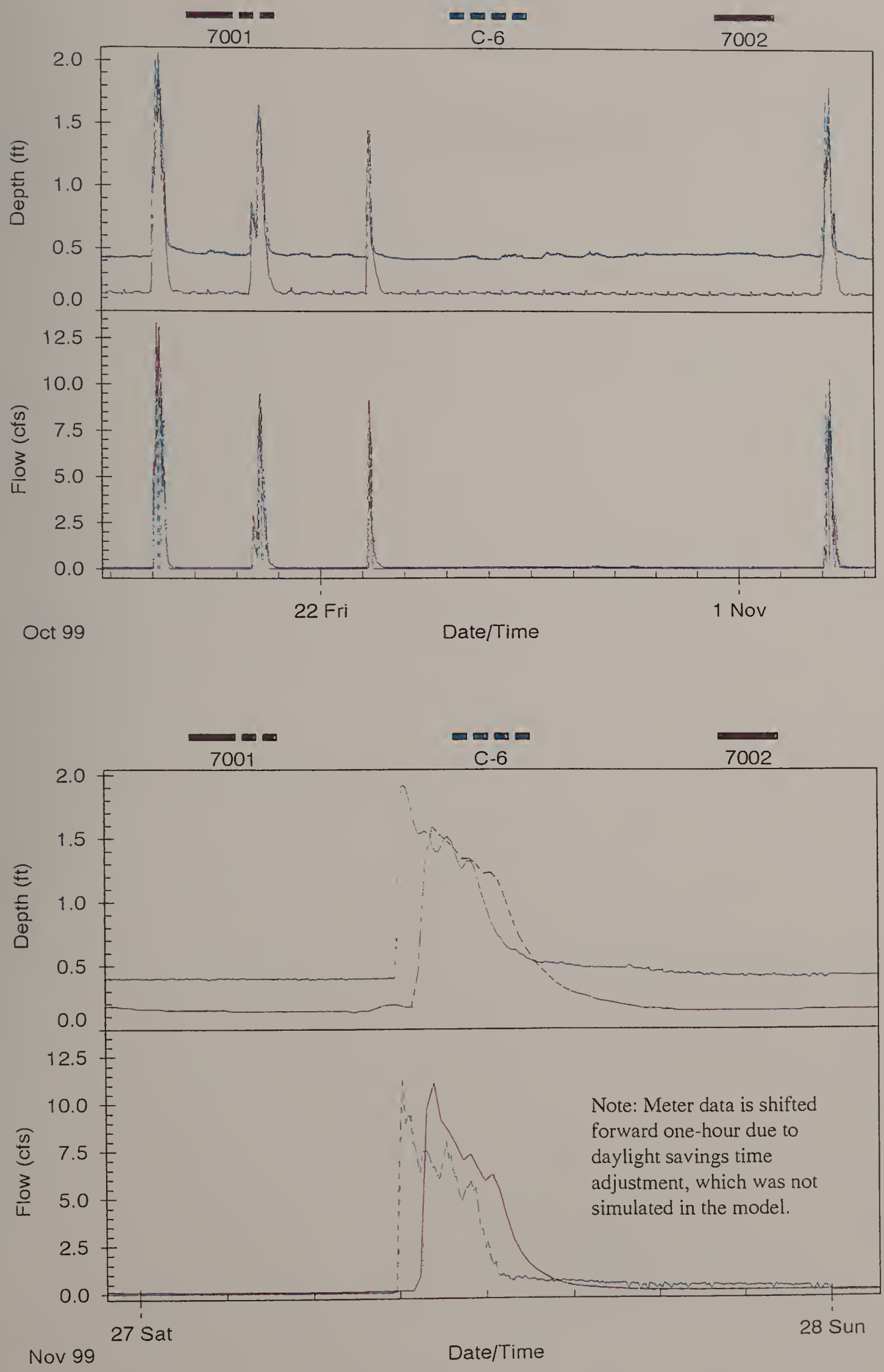
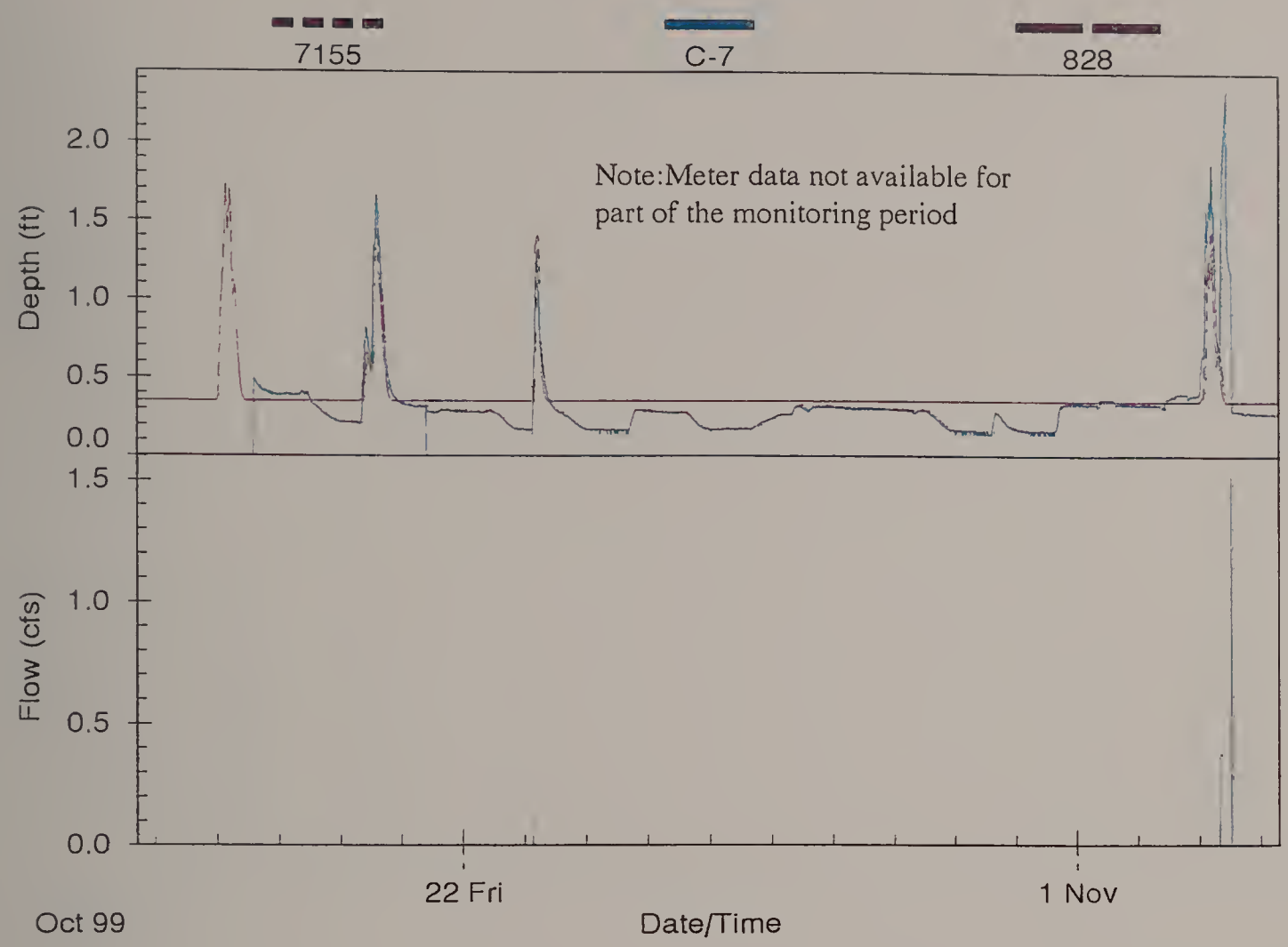


FIGURE C-13. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-6



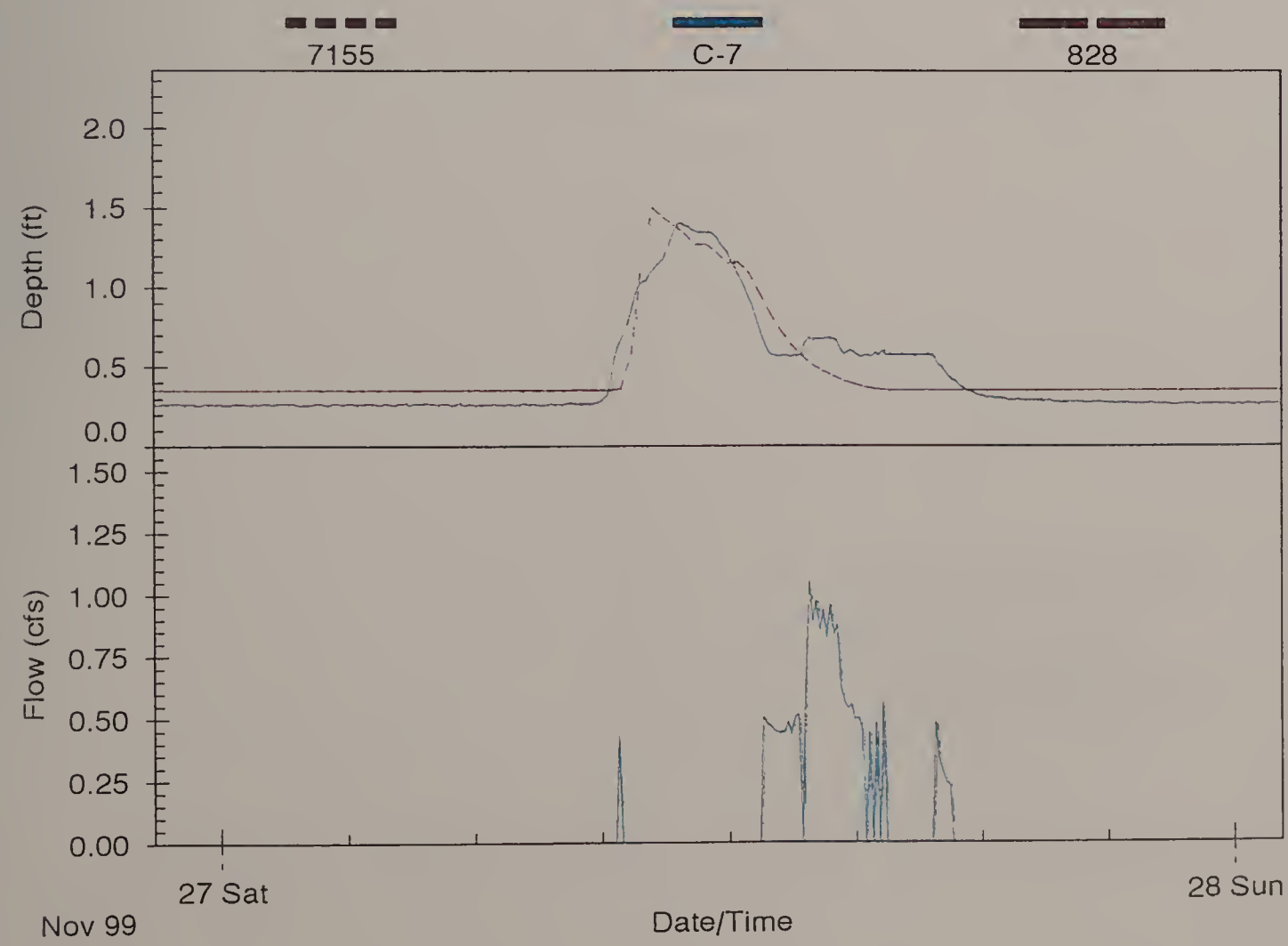


FIGURE C-14. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-7

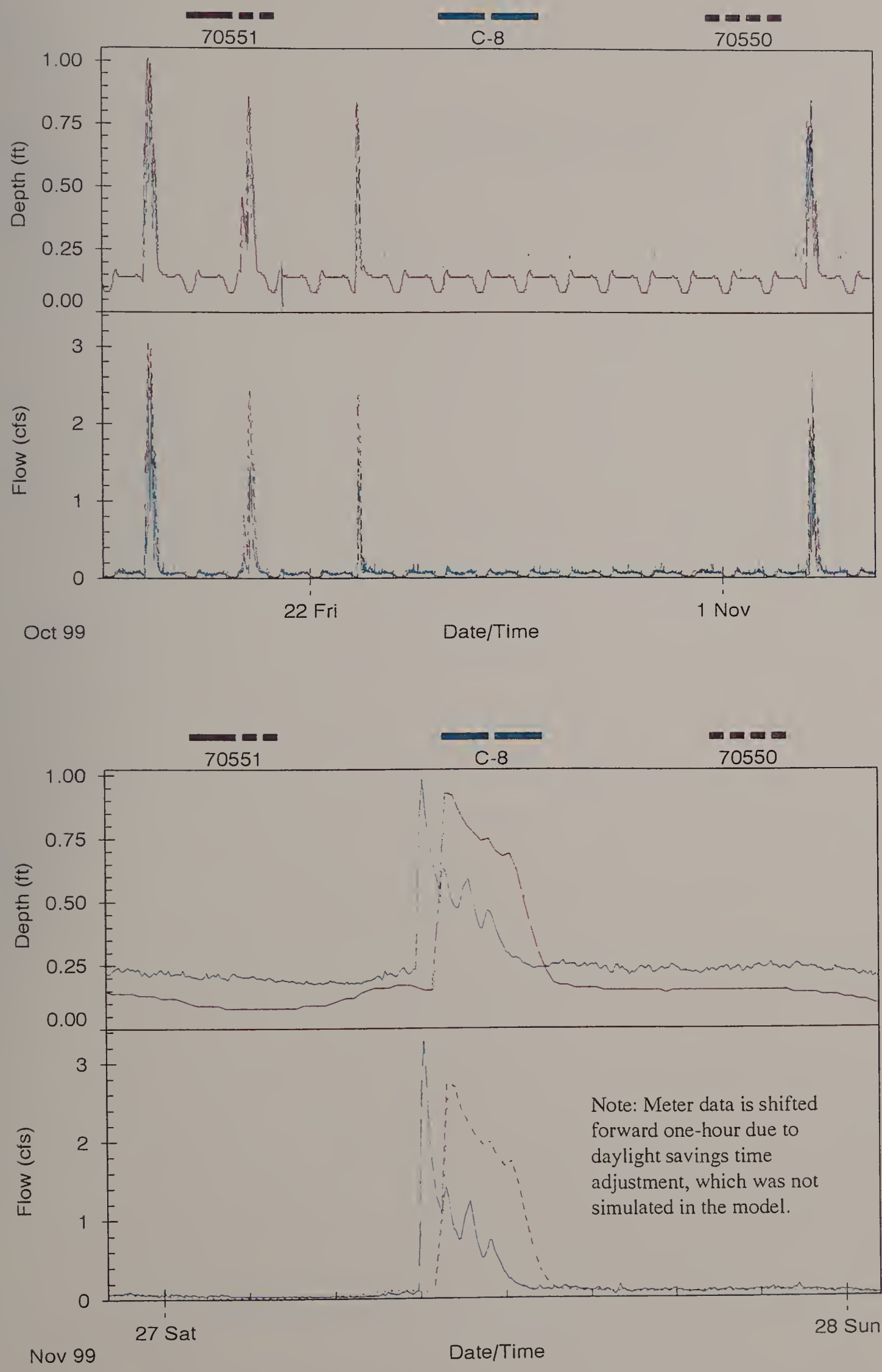
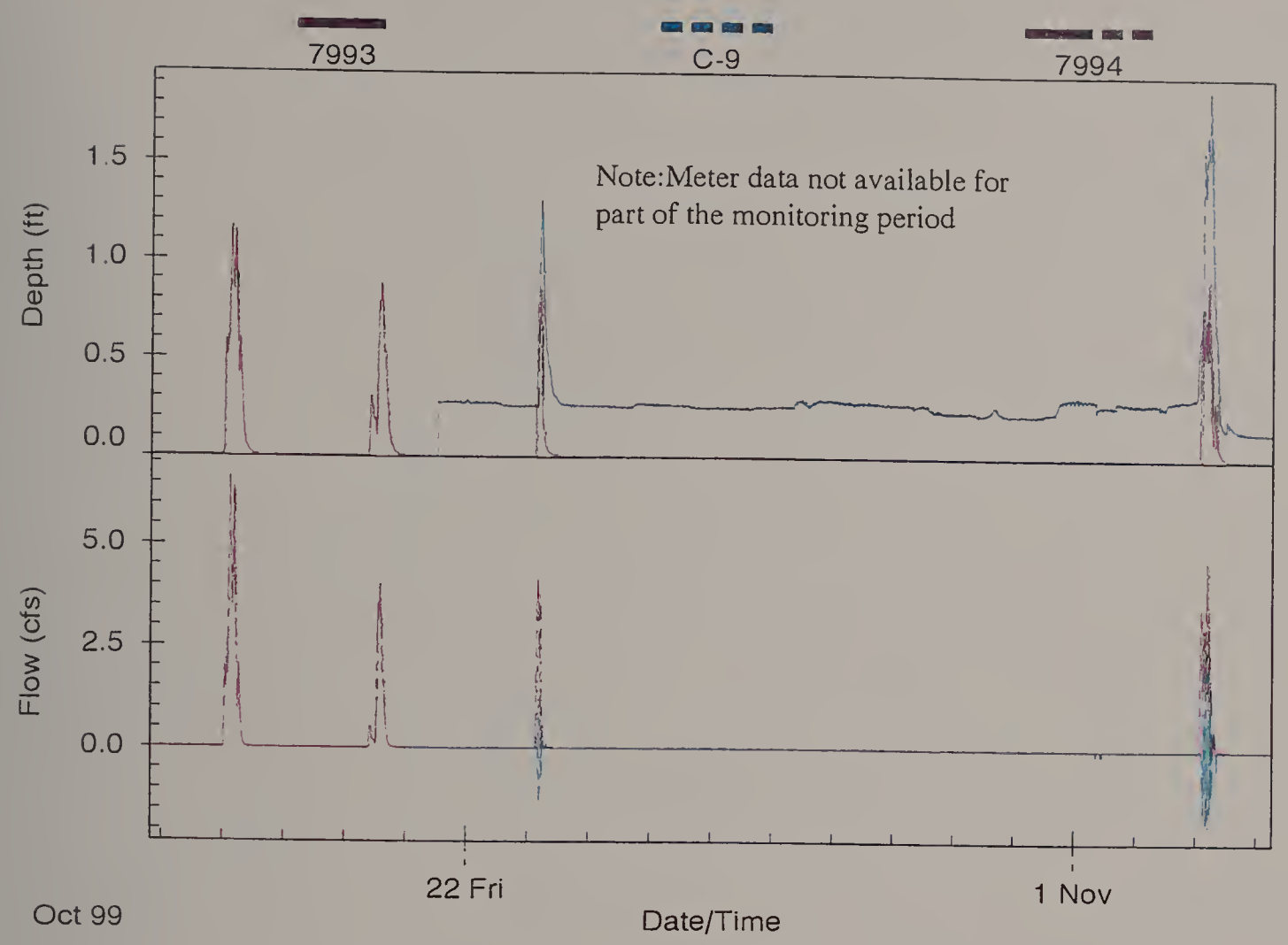


FIGURE C-15. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-8



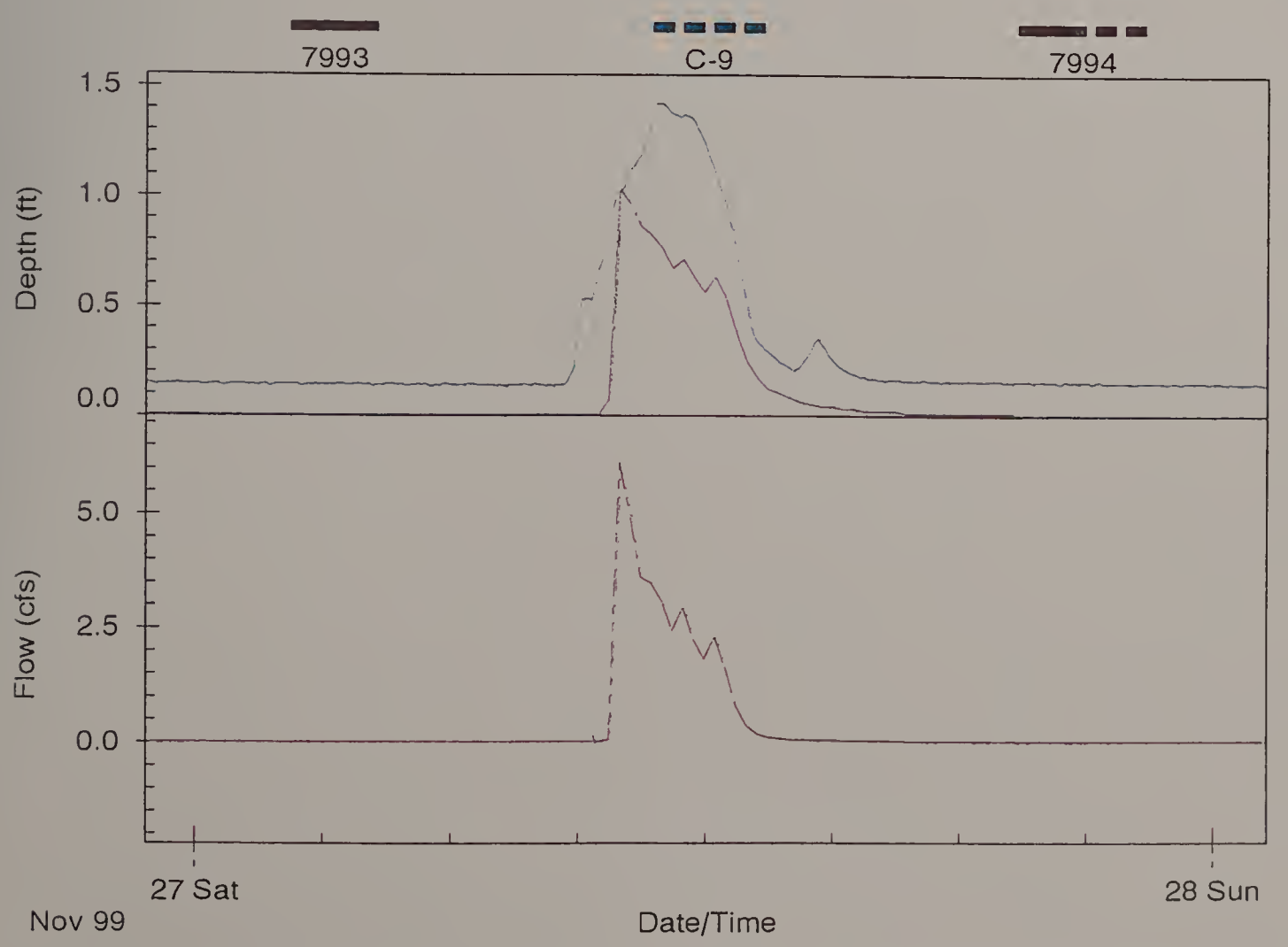


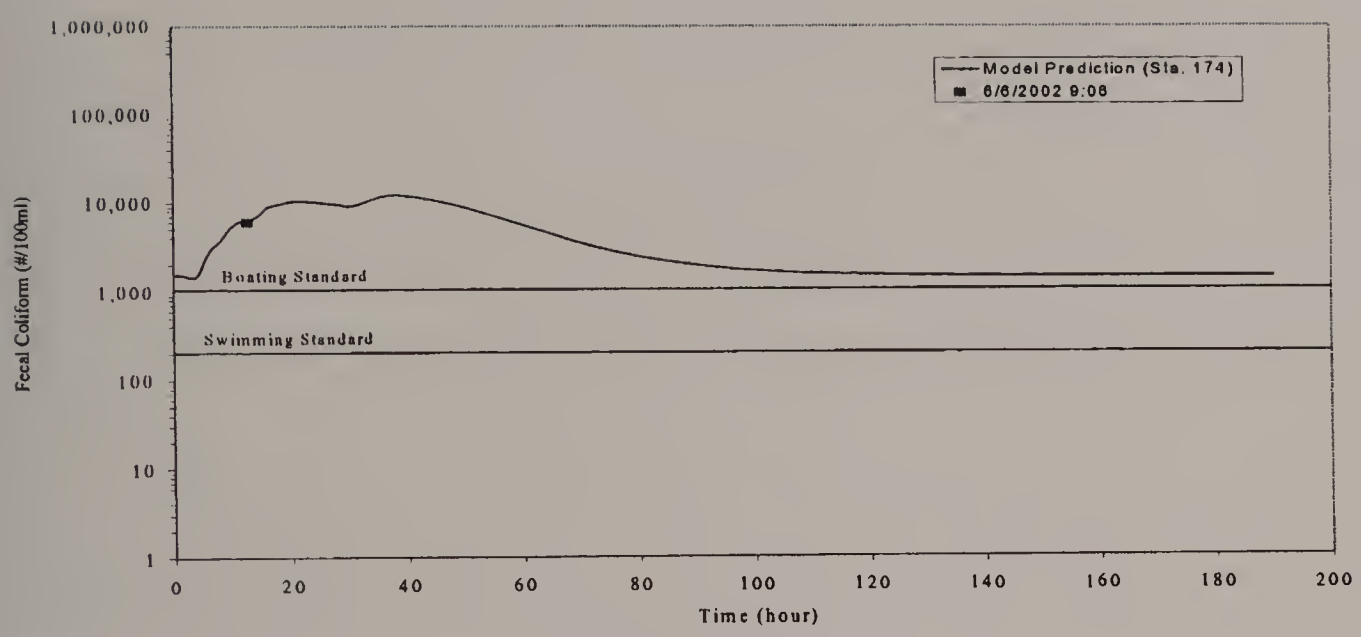
FIGURE C-16. COMPARISON OF MEASURED AND SIMULATED FLOW METER C-9

Appendix E

Appendix E

APPENDIX E

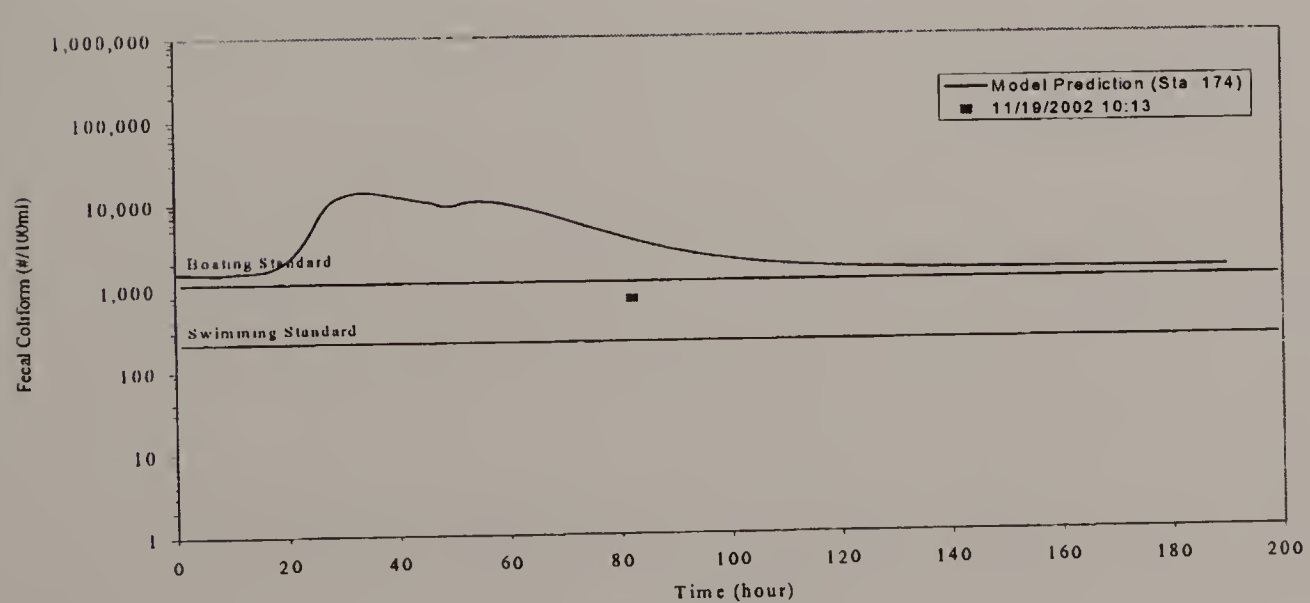
WATER QUALITY MODEL
CONCENTRATION VS. TIME PLOTS



JUNE 6, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION

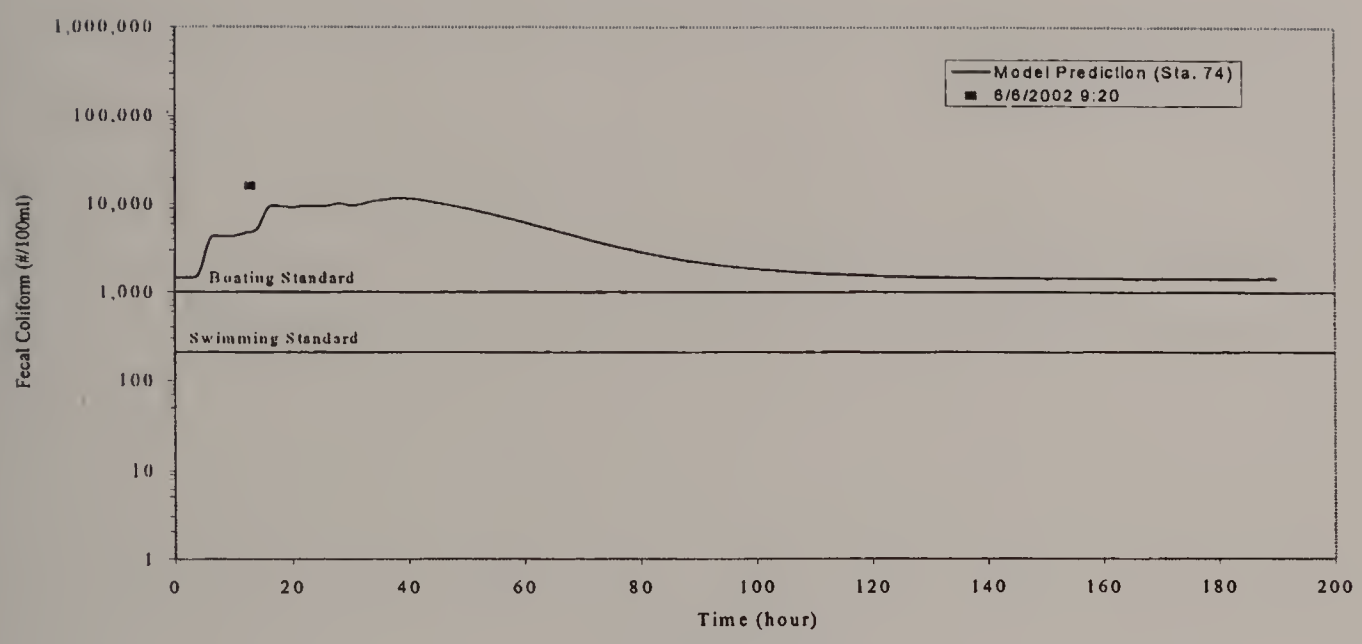
DURING SEPTEMBER 23, 2002 STORM



NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

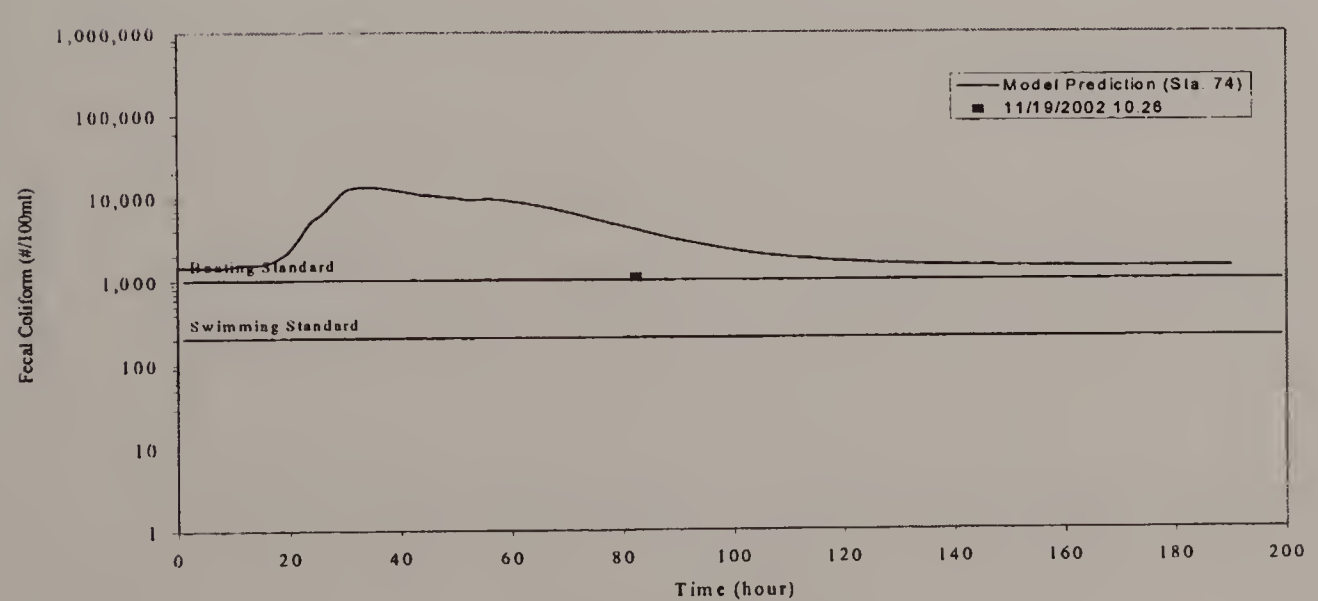
SAMPLING STATION 174



JUNE 6, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION

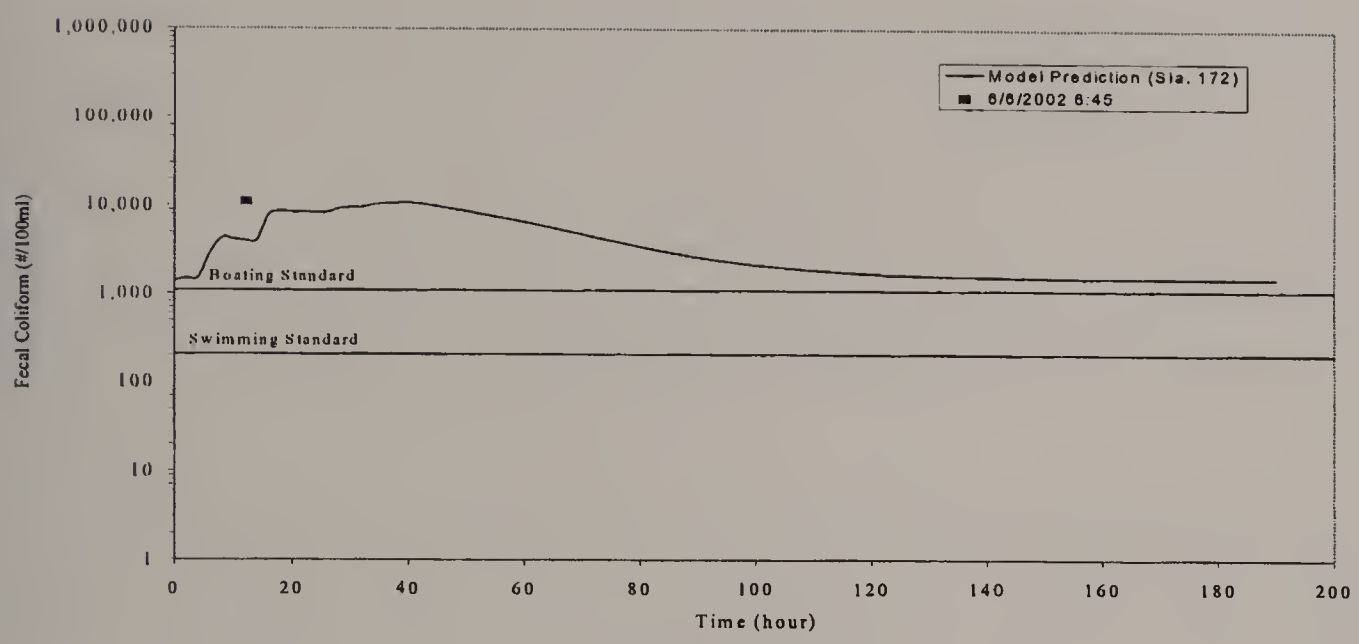
DURING SEPTEMBER 23, 2002 STORM



NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

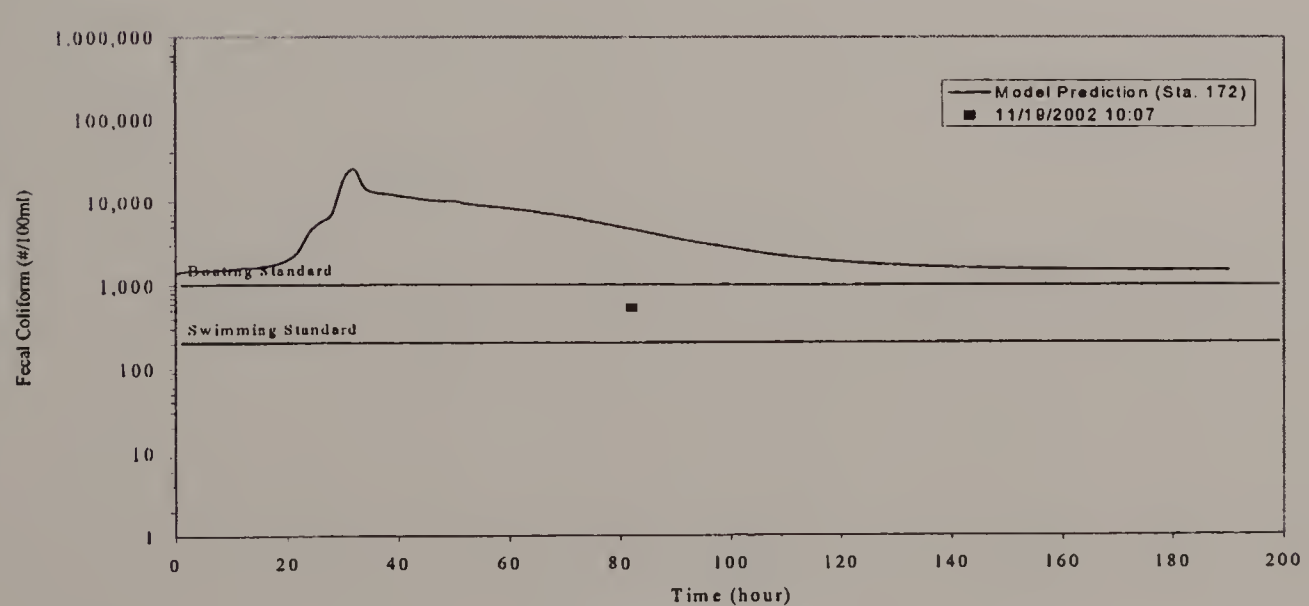
SAMPLING STATION 74



JUNE 6, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION

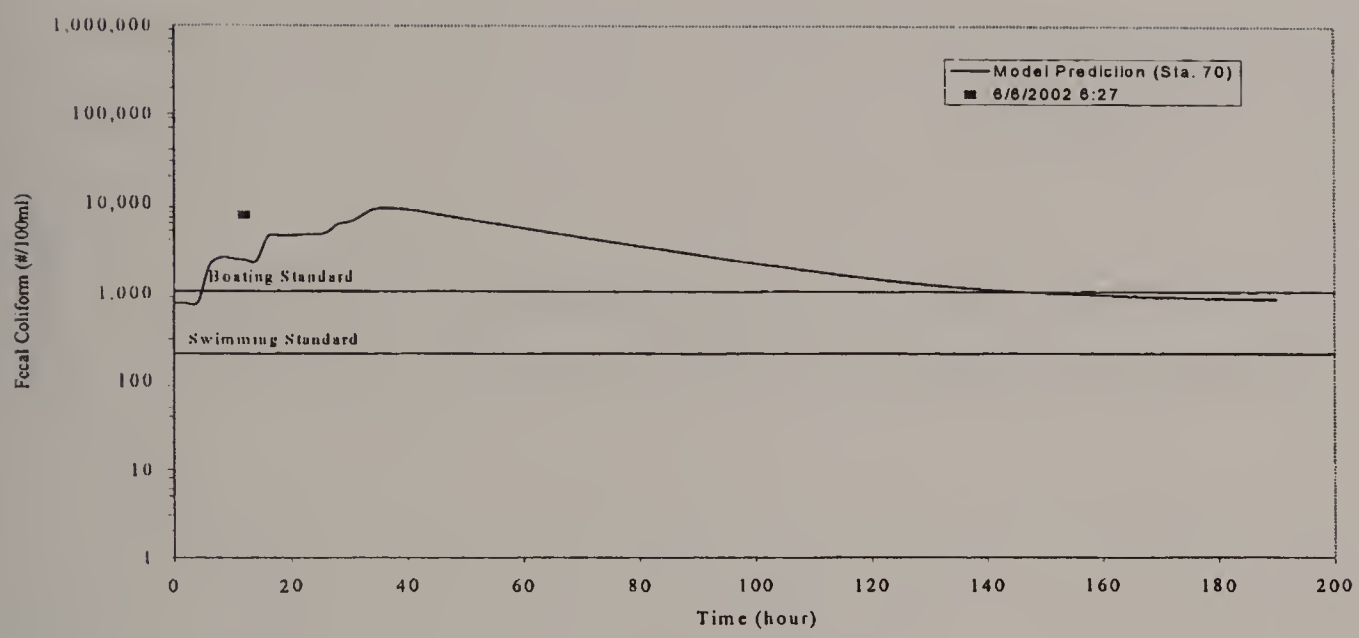
DURING SEPTEMBER 23, 2002 STORM



NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

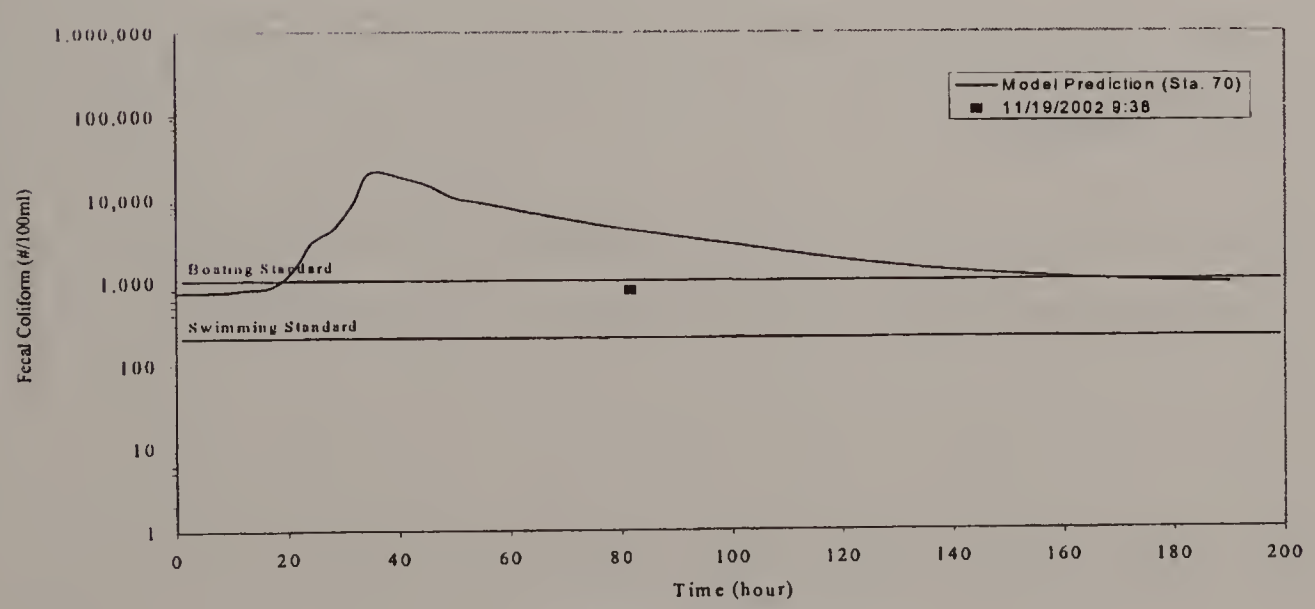
SAMPLING STATION 172



JUNE 6, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION

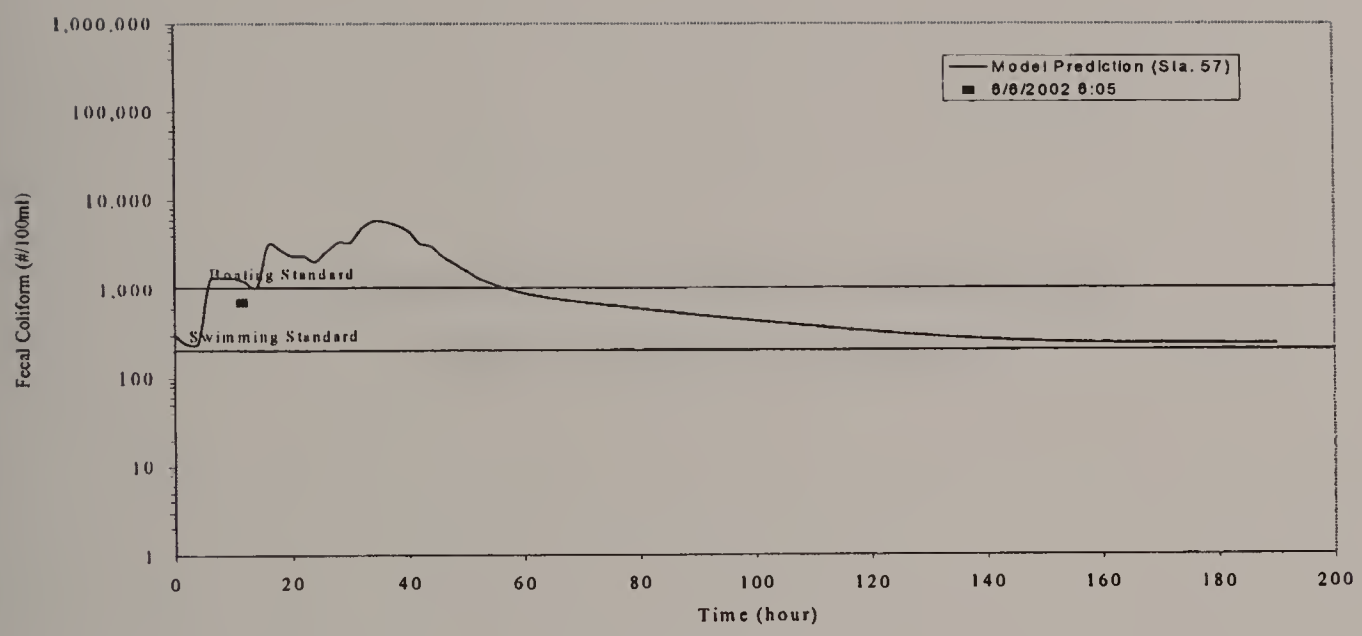
DURING SEPTEMBER 23, 2002 STORM



NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

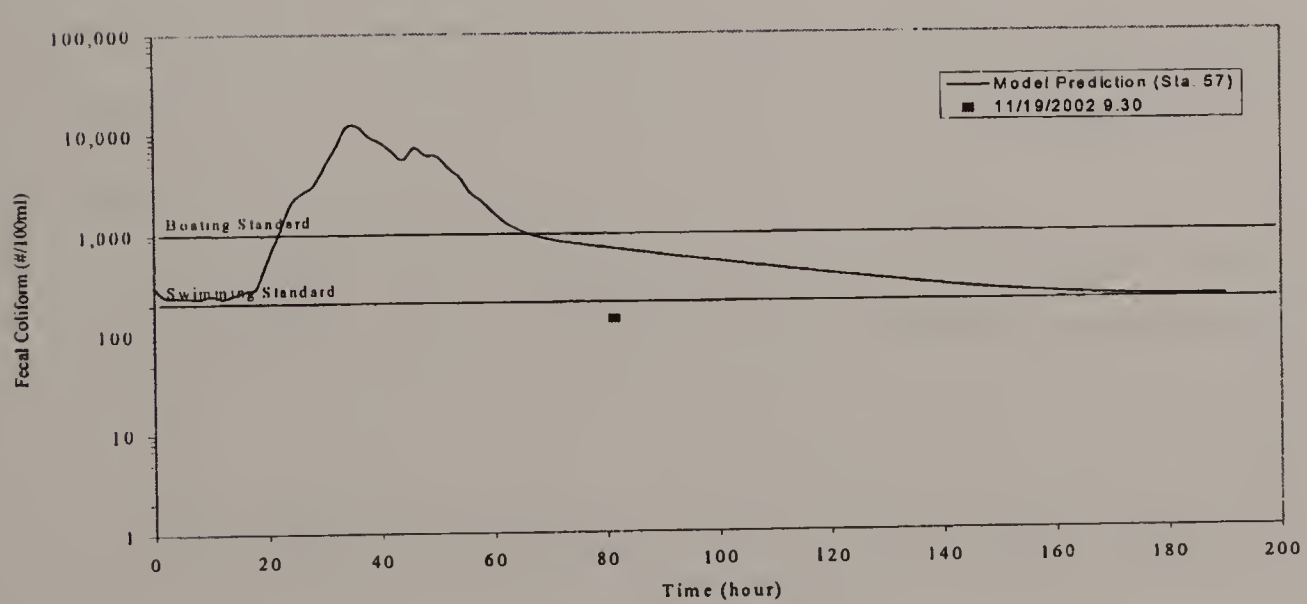
SAMPLING STATION 70



JUNE 6, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION

DURING SEPTEMBER 23, 2002 STORM



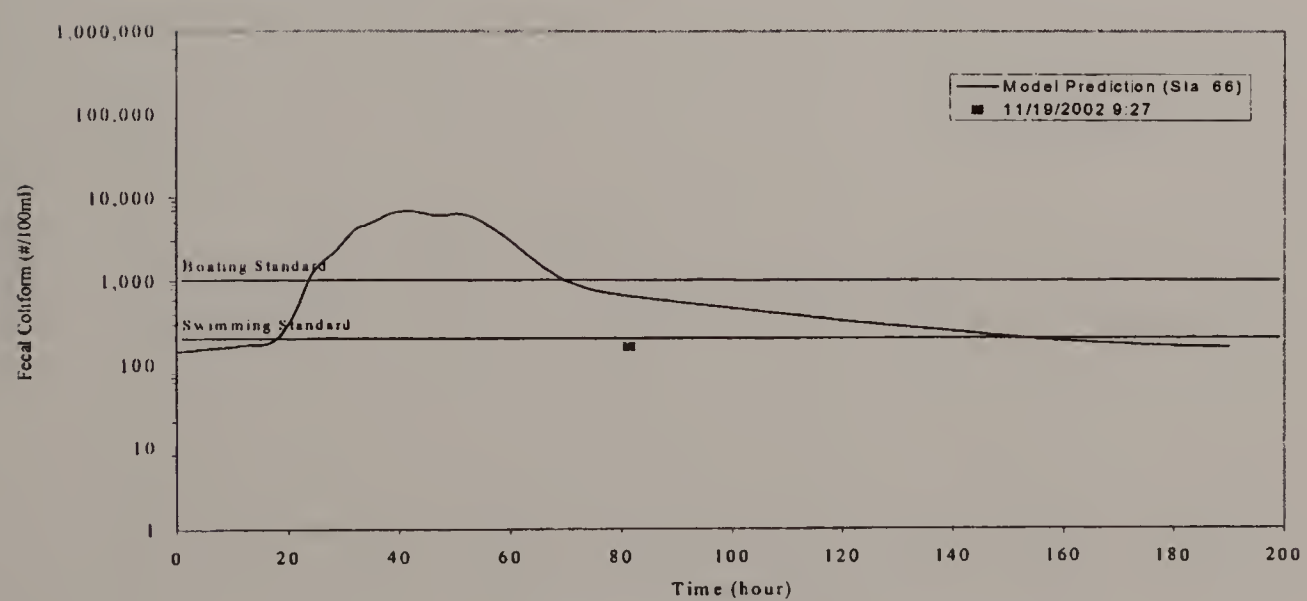
NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

SAMPLING STATION 57

NO SAMPLE WAS TAKEN AT THIS STATION
DURING JUNE 6-7, 2002 STORM

NO SAMPLE WAS TAKEN AT THIS STATION
DURING SEPTEMBER 23, 2002 STORM

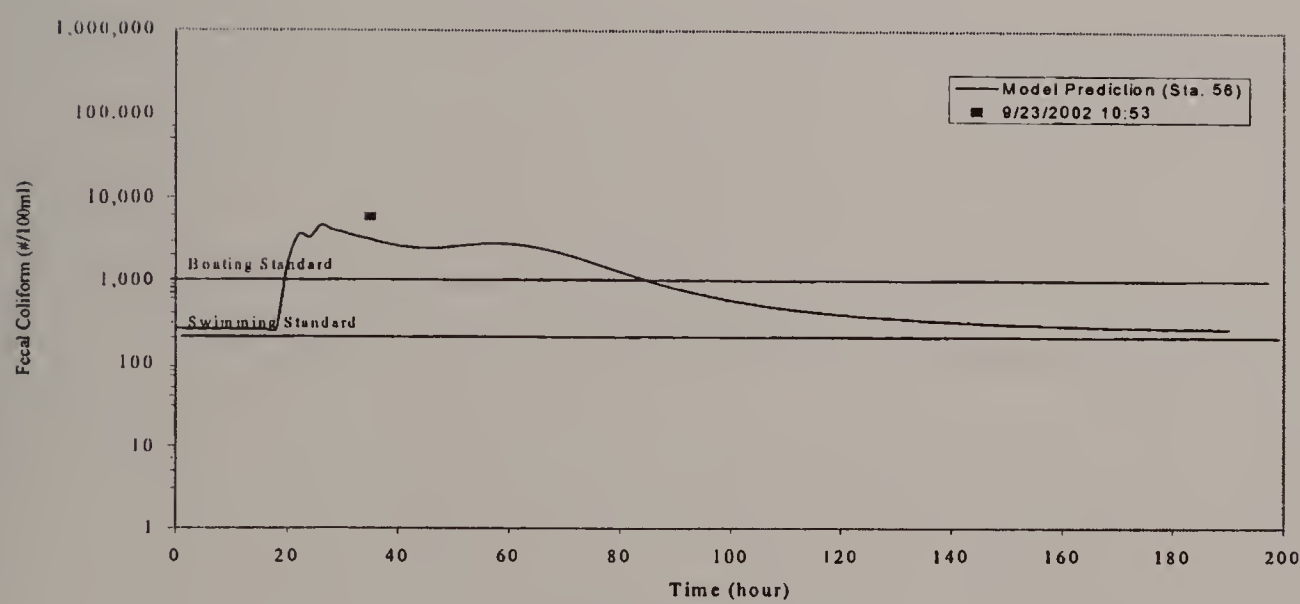


NOVEMBER 16, 2002 STORM

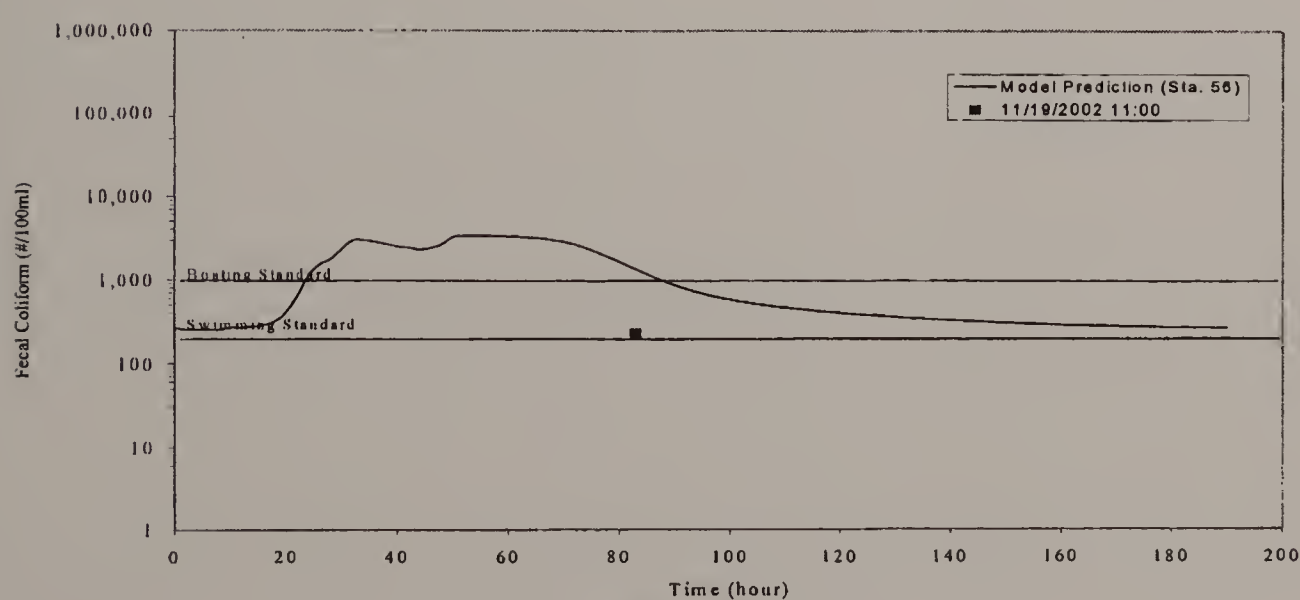
ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

SAMPLING STATION 66

NO SAMPLE WAS TAKEN AT THIS STATION
DURING JUNE 6-7, 2002 STORM

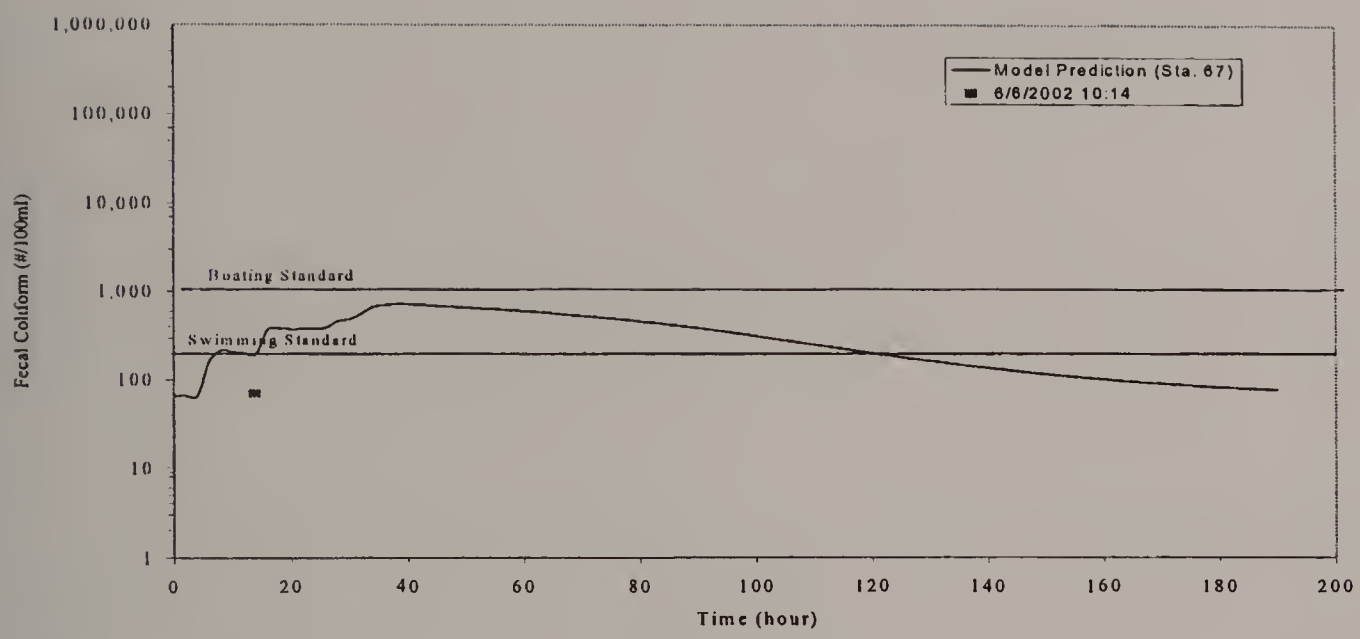


SEPTEMBER 22, 2002 STORM

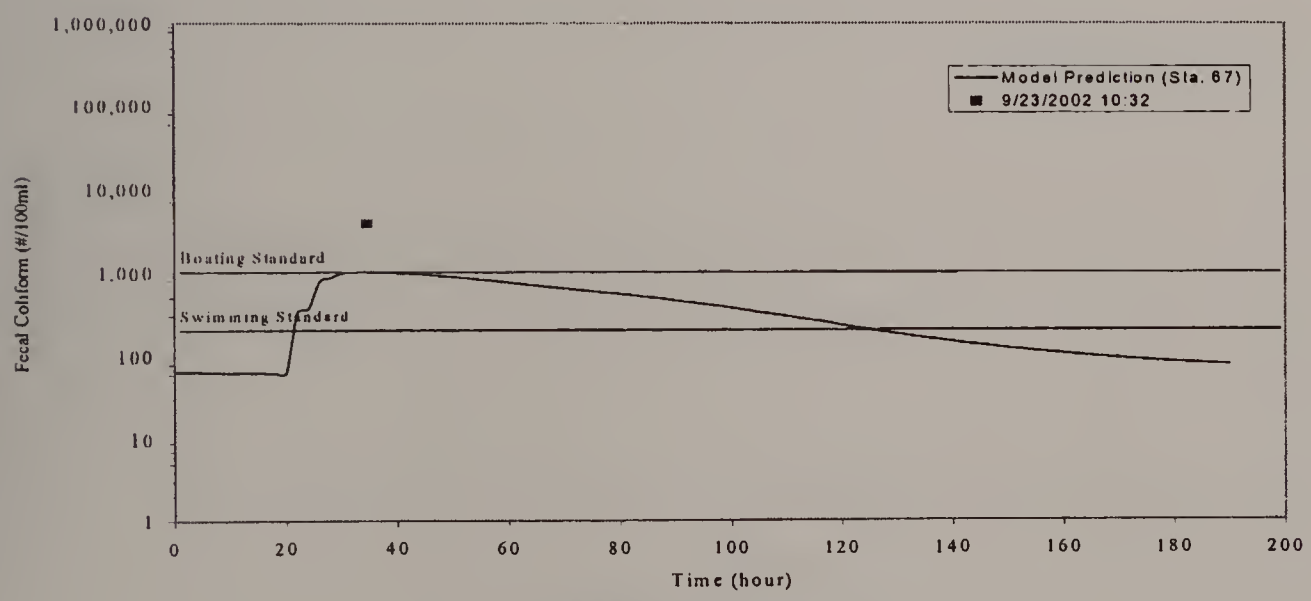


NOVEMBER 16, 2002 STORM

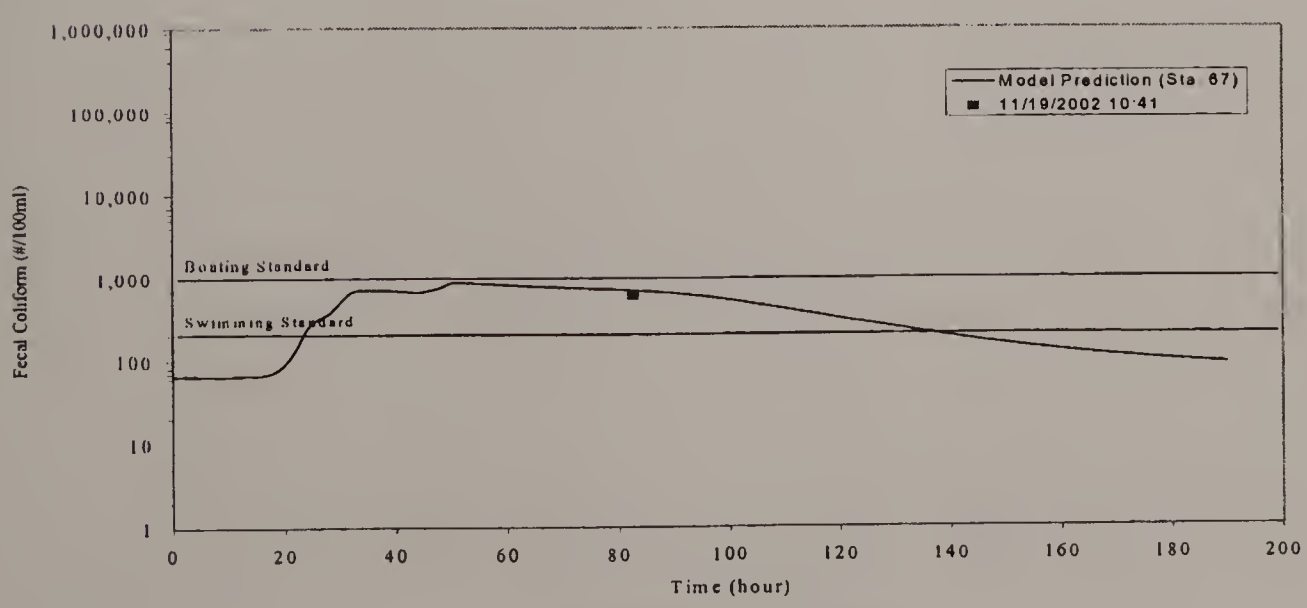
ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES
SAMPLING STATION 56



JUNE 6, 2002 STORM



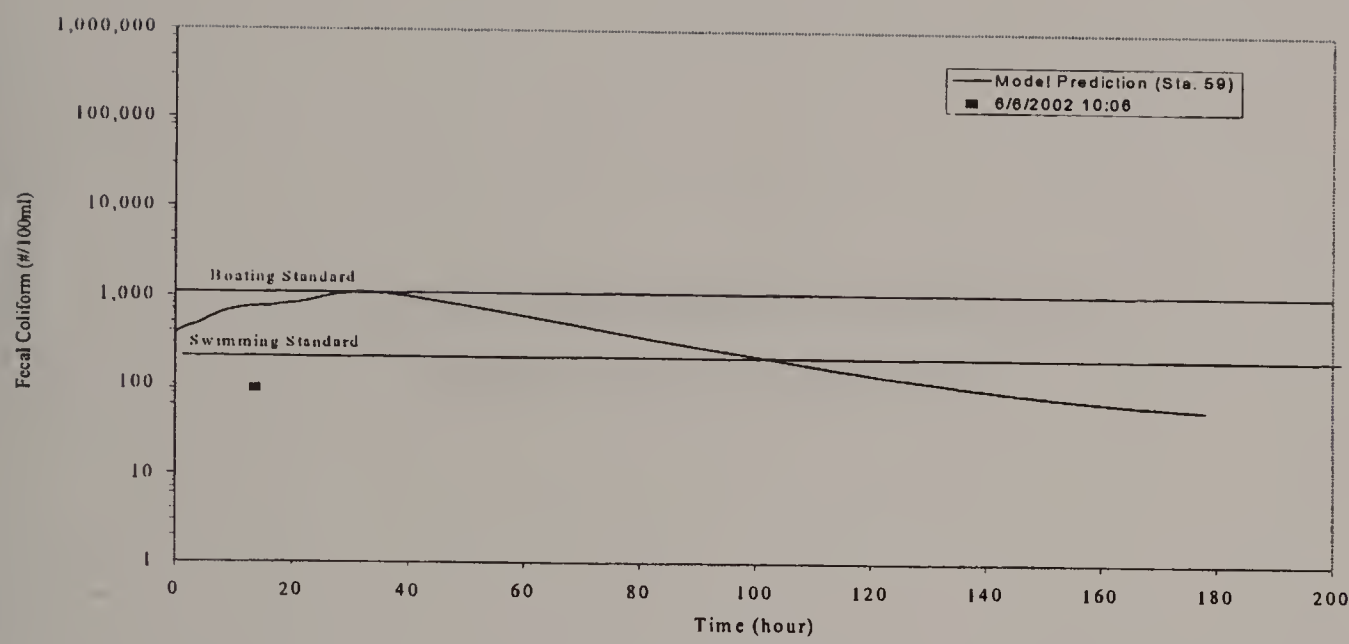
SEPTEMBER 22, 2002 STORM



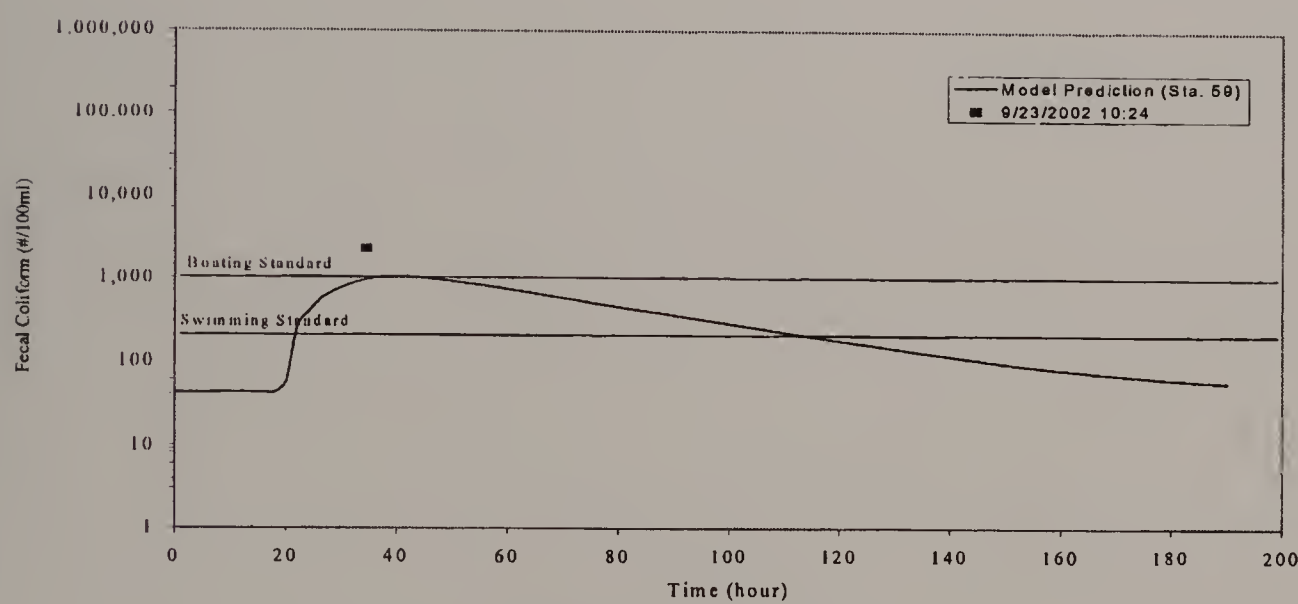
NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

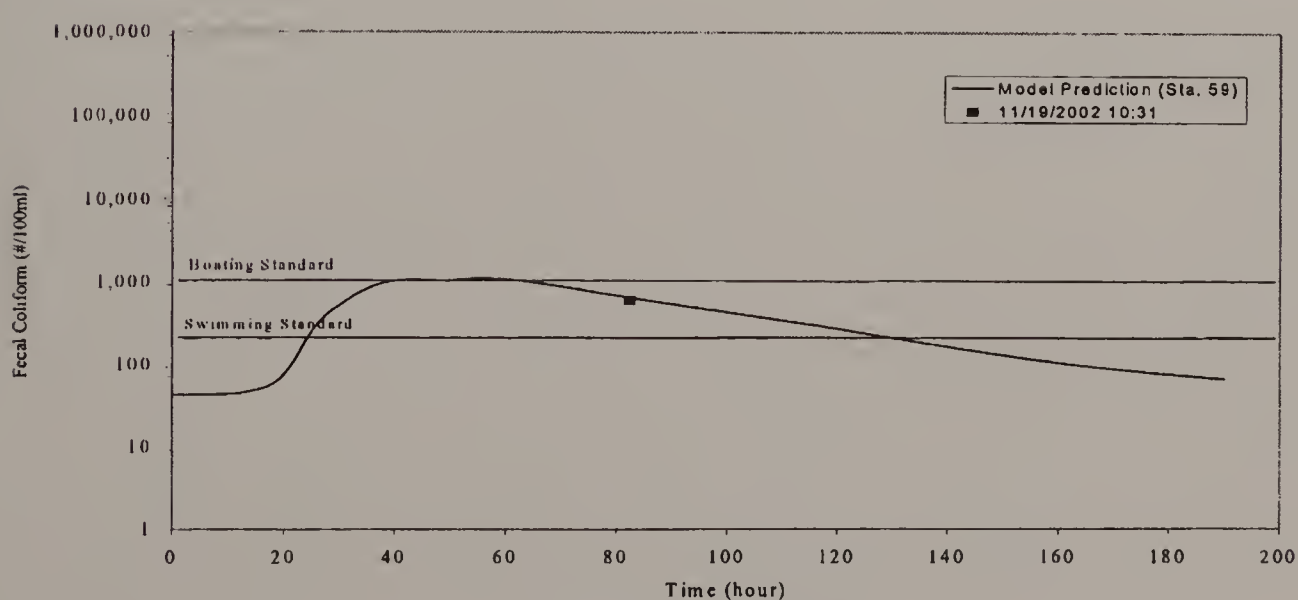
SAMPLING STATION 67



JUNE 6, 2002 STORM



SEPTEMBER 22, 2002 STORM



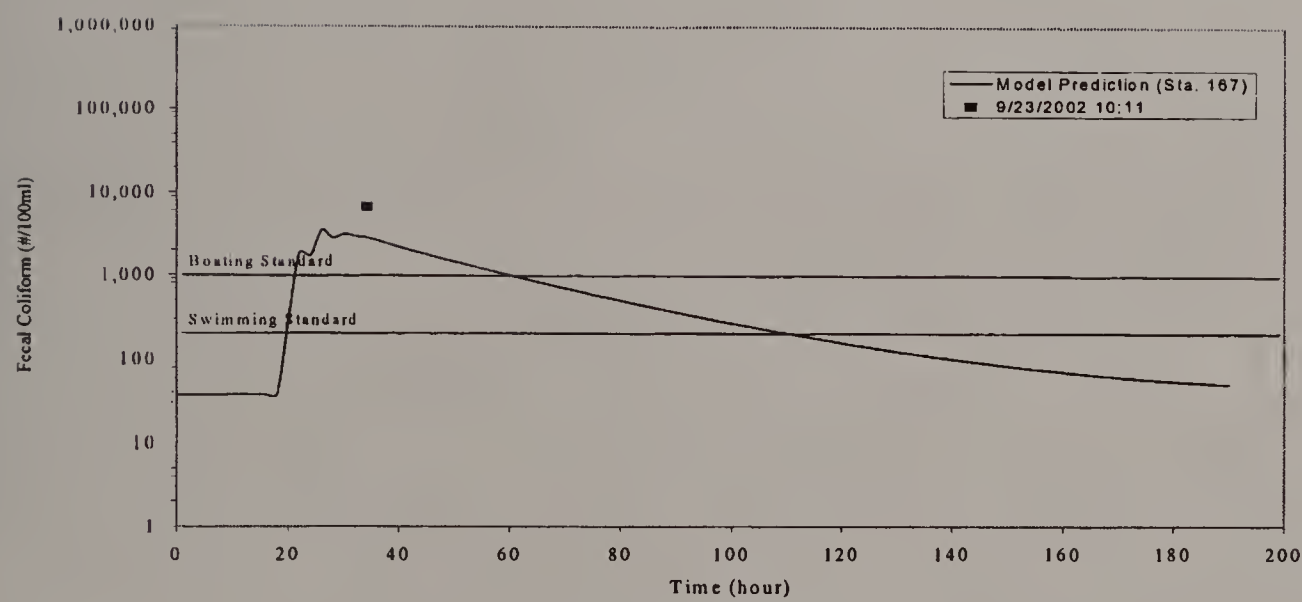
NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

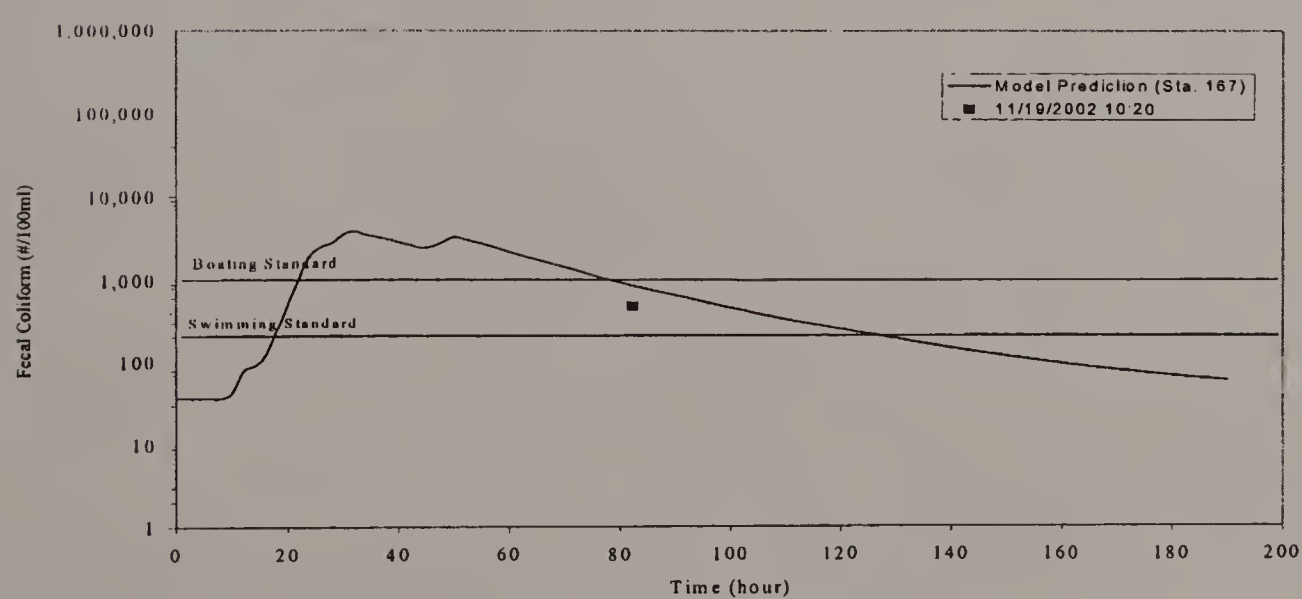
SAMPLING STATION 59

NO SAMPLE WAS TAKEN AT THIS STATION

DURING JUNE 6-7, 2002 STORM



SEPTEMBER 22, 2002 STORM



NOVEMBER 16, 2002 STORM

ALEWIFE BROOK/MYSTIC RIVER FECAL COLIFORM PROFILES

SAMPLING STATION 167

Appendix F

Appendix F

APPENDIX F

COST CURVES AND SPREADSHEETS

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidated Storage Conduit, 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	145,103,012
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	145,103,012
Total NPV - Capital Cost:	$	135,729,927

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	224,963
30 year O&M Cost Average:	$	209,965
Total O&M Cost:	$	6,298,964
Total NPV - O&M Costs:	$	3,754,252

	Total Cost	NPV
Capital Costs	$ 145,103,012	$135,729,927
O&M Costs:	$ 6,298,964	$ 3,754,252
TOTAL:	$ 151,401,976	$139,484,179

Notes/Assumptions:

Note: Adjustment of capital cost to April 2003 ENR CCI of 7717 is made within the LCCA spreadsheet

#2

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidated Storage Conduit, 2 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	115,040,731
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	115,040,731
Total NPV - Capital Cost:	$	107,609,551

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	224,963
30 year O&M Cost Average:	$	209,965
Total O&M Cost:	$	6,298,964
Total NPV - O&M Costs:	$	3,754,252

	Total Cost	NPV
Capital Costs	$ 115,040,731	$107,609,551
O&M Costs:	$ 6,298,964	$ 3,754,252
TOTAL:	$ 121,339,695	$111,363,804

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidated Storage Conduit, 4 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	113,428,239
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	113,428,239
Total NPV - Capital Cost:	$	106,101,220

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	224,963
30 year O&M Cost Average:	$	209,965
Total O&M Cost:	$	6,298,964
Total NPV - O&M Costs:	$	3,754,252

	Total Cost	NPV
Capital Costs	$ 113,428,239	$106,101,220
O&M Costs:	$ 6,298,964	$ 3,754,252
TOTAL:	$ 119,727,203	$109,855,472

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Storage Tank, 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	141,558,900
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	141,558,900
Total NPV - Capital Cost:	$	132,414,751

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	757,206
30 year O&M Cost Average:	$	706,726
Total O&M Cost:	$	21,201,768
Total NPV - O&M Costs:	$	12,636,489

	Total Cost	NPV
Capital Costs	$ 141,558,900	$132,414,751
O&M Costs:	$ 21,201,768	$ 12,636,489
TOTAL:	$ 162,760,668	$145,051,240

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Storage Tank, 2 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	112,641,478
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	112,641,478
Total NPV - Capital Cost:	$	105,365,281

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	521,606
30 year O&M Cost Average:	$	486,832
Total O&M Cost:	$	14,604,968
Total NPV - O&M Costs:	$	8,704,723

	Total Cost	NPV
Capital Costs	$ 112,641,478	$105,365,281
O&M Costs:	$ 14,604,968	$ 8,704,723
TOTAL:	$ 127,246,446	$114,070,003

Notes/Assumptions:

#6

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Storage Tank, 4 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	104,573,753
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	104,573,753
Total NPV - Capital Cost:	$	97,818,699

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	521,606
30 year O&M Cost Average:	$	486,832
Total O&M Cost:	$	14,604,968
Total NPV - O&M Costs:	$	8,704,723

	Total Cost	NPV
Capital Costs	$ 104,573,753	$ 97,818,699
O&M Costs:	$ 14,604,968	$ 8,704,723
TOTAL:	$ 119,178,721	$106,523,422

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Prim. Treat., 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	157,159,310
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	157,159,310
Total NPV - Capital Cost:	$	147,007,436

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	498,952
30 year O&M Cost Average:	$	465,689
Total O&M Cost:	$	13,970,656
Total NPV - O&M Costs:	$	8,326,666

	Total Cost	NPV
Capital Costs	$ 157,159,310	$147,007,436
O&M Costs:	$ 13,970,656	$ 8,326,666
TOTAL:	$ 171,129,966	$155,334,101

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Prim. Treat., 2 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	128,122,873
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	128,122,873
Total NPV - Capital Cost:	$	119,846,638

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	498,952
30 year O&M Cost Average:	$	465,689
Total O&M Cost:	$	13,970,656
Total NPV - O&M Costs:	$	8,326,666

	Total Cost	NPV
Capital Costs	$ 128,122,873	$119,846,638
O&M Costs:	$ 13,970,656	$ 8,326,666
TOTAL:	$ 142,093,529	$128,173,304

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Consolidation Conduit to Screen/Disinf., 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	108,311,658
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	108,311,658
Total NPV - Capital Cost:	$	101,315,150

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	78,603
Total Labor Costs	$	2,200,884
Peak Annual O&M Cost:	$	341,722
30 year O&M Cost Average:	$	318,941
Total O&M Cost:	$	9,568,216
Total NPV - O&M Costs:	$	5,702,763

	Total Cost	NPV
Capital Costs	$ 108,311,658	$101,315,150
O&M Costs:	$ 9,568,216	$ 5,702,763
TOTAL:	$ 117,879,874	$107,017,913

Notes/Assumptions:

#10

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Separation w/Storage Conduit, 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	145,271,092
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	145,271,092
Total NPV - Capital Cost:	$	135,887,150

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	222,755
30 year O&M Cost Average:	$	207,905
Total O&M Cost:	$	6,237,140
Total NPV - O&M Costs:	$	3,717,405

	Total Cost	NPV
Capital Costs	$ 145,271,092	$135,887,150
O&M Costs:	$ 6,237,140	$ 3,717,405
TOTAL:	$ 151,508,232	$139,604,554

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Separation w/Storage Conduit, 2 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	111,641,529
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	111,641,529
Total NPV - Capital Cost:	$	104,429,924

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	222,755
30 year O&M Cost Average:	$	207,905
Total O&M Cost:	$	6,237,140
Total NPV - O&M Costs:	$	3,717,405

	Total Cost	NPV
Capital Costs	$ 111,641,529	$104,429,924
O&M Costs:	$ 6,237,140	$ 3,717,405
TOTAL:	$ 117,878,669	$108,147,329

Notes/Assumptions:

#12

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Separation w/Storage Conduit, 4 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	97,949,567
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	97,949,567
Total NPV - Capital Cost:	$	91,622,410

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	60,933
Total Labor Costs	$	1,706,124
Peak Annual O&M Cost:	$	222,755
30 year O&M Cost Average:	$	207,905
Total O&M Cost:	$	6,237,140
Total NPV - O&M Costs:	$	3,717,405

	Total Cost	NPV
Capital Costs	$ 97,949,567	$ 91,622,410
O&M Costs:	$ 6,237,140	$ 3,717,405
TOTAL:	$ 104,186,707	$ 95,339,814

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Separation w/Conduit & Tank, 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	140,372,529
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	140,372,529
Total NPV - Capital Cost:	$	131,305,015

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	157,206
Total Labor Costs	$	4,401,768
Peak Annual O&M Cost:	$	480,458
30 year O&M Cost Average:	$	448,427
Total O&M Cost:	$	13,452,824
Total NPV - O&M Costs:	$	8,018,032

	Total Cost	NPV
Capital Costs	$ 140,372,529	$131,305,015
O&M Costs:	$ 13,452,824	$ 8,018,032
TOTAL:	$ 153,825,353	$139,323,047

Notes/Assumptions:

#14

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Separation w/Scr. & Disinf., 0 OF/Yr.
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	130,461,656
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	130,461,656
Total NPV - Capital Cost:	$	122,034,345

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	78,603
Total Labor Costs	$	2,200,884
Peak Annual O&M Cost:	$	335,787
30 year O&M Cost Average:	$	313,401
Total O&M Cost:	$	9,402,036
Total NPV - O&M Costs:	$	5,603,718

	Total Cost	NPV
Capital Costs	$ 130,461,656	$122,034,345
O&M Costs:	$ 9,402,036	$ 5,603,718
TOTAL:	$ 139,863,692	$127,638,063

Notes/Assumptions:

#15

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Sewer Separation, Alternative A
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	73,682,839
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	73,682,839
Total NPV - Capital Cost:	$	68,923,217

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	-
Total Labor Costs	$	-
Peak Annual O&M Cost:	$	-
30 year O&M Cost Average:	-$	5,008
Total O&M Cost:	-$	150,248
Total NPV - O&M Costs:	-$	89,549

	Total Cost	NPV
Capital Costs	$ 73,682,839	$ 68,923,217
O&M Costs:	-$ 150,248	-$ 89,549
TOTAL:	$ 73,532,591	$ 68,833,668

Notes/Assumptions:

#16

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Partial Sewer Separation, Alternative B
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	82,517,413
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	82,517,413
Total NPV - Capital Cost:	$	77,187,112

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	-
Total Labor Costs	$	-
Peak Annual O&M Cost:	$	-
30 year O&M Cost Average:	-$	7,154
Total O&M Cost:	-$	214,620
Total NPV - O&M Costs:	-$	127,916

	Total Cost	NPV
Capital Costs	$ 82,517,413	$ 77,187,112
O&M Costs:	-$ 214,620	-$ 127,916
TOTAL:	$ 82,302,793	$ 77,059,196

Notes/Assumptions:

#17

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Targeted Separation, Alt. A w/ All CAM002
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	95,749,395
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	95,749,395
Total NPV - Capital Cost:	$	89,564,360

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	-
Total Labor Costs	$	-
Peak Annual O&M Cost:	$	-
30 year O&M Cost Average:	-$	8,773
Total O&M Cost:	-$	263,200
Total NPV - O&M Costs:	-$	156,870

	Total Cost	NPV
Capital Costs	$ 95,749,395	$ 89,564,360
O&M Costs:	-$ 263,200	-$ 156,870
TOTAL:	$ 95,486,195	$ 89,407,490

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Targeted Sewer Separation, CAM004 Only
Date: 28-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		3
Base Construction Cost:	$	71,828,683
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	71,828,683
Total NPV - Capital Cost:	$	67,188,832

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	-
Total Labor Costs	$	-
Peak Annual O&M Cost:	$	-
30 year O&M Cost Average:	-$	3,815
Total O&M Cost:	-$	114,464
Total NPV - O&M Costs:	-$	68,222

	Total Cost	NPV
Capital Costs	$ 71,828,683	$ 67,188,832
O&M Costs:	-$ 114,464	-$ 68,222
TOTAL:	$ 71,714,219	$ 67,120,610

Notes/Assumptions:

MWRA: Life Cycle Cost Analysis

Life Cycle Cost Analysis Summary Sheet

Preparer: E. Al-Beirouty
Project: Total Sewer Separation
Date: 30-Apr-03

CAPITAL COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate		3.41%
Term of Analysis (years)		30 years
Construction Duration (years)		11
Base Construction Cost:	$	172,298,766
Misc. Reserve	$	-
Engineering and CM Cost:	$	-
Replacement Capital Cost:	$	-
Total Capital Cost:	$	172,298,766
Total NPV - Capital Cost:	$	141,656,144

OPERATING COST SUMMARY

Discount Rate:		6.00%
Inflation Rate:		2.50%
Effective Discount Rate:		3.41%
Term of Analysis (years)		30 years
Labor Cost/year:	$	-
Total Labor Costs	$	-
Peak Annual O&M Cost:	$	-
30 year O&M Cost Average:	-$	14,007
Total O&M Cost:	-$	420,200
Total NPV - O&M Costs:	-$	223,314

	Total Cost	NPV
Capital Costs	$ 172,298,766	$141,656,144
O&M Costs:	-$ 420,200	-$ 223,314
TOTAL:	$ 171,878,566	$141,432,830

Notes/Assumptions:

Grant, Geoffrey

From: Walker, Donald
Sent: Thursday, April 24, 2003 4:35 PM
To: Grant, Geoffrey
Subject: FW: LCCA Economic Assumptions

-----Original Message-----
From: Brocard, Dominique
Sent: Wednesday, April 09, 2003 4:55 PM
To: Walker, Donald
Subject: FW: LCCA Economic Assumptions

-----Original Message-----
From: Vittori, Dede [mailto:Dede.Vittori@mwra.state.ma.us]
Sent: Wednesday, April 09, 2003 2:18 PM
To: Brocard, Dominique
Subject: FW: LCCA Economic Assumptions

Current economic factors for MWRA LCCAs -

> Discount Rate: 6.0%
>
> Inflation Rate: 2.5%
>
> Effective Discount Rate: 3.4%
>
> Average Salary: $57,000
>
Fringe Benefit Rate 20%

COST INDEXES

CONSTRUCTION COST INDEX

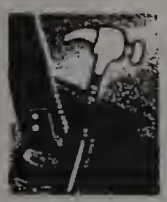
The CCI increased 0.1% this month, compared to a 0.3% decline in the same month a year ago, pushing inflation to 2.4%.

20-CITY: 1913=100	APRIL 2003 INDEX VALUE	% CHG. MONTH	% CHG. YEAR
CONSTRUCTION COST	6635.49	+0.1	+2.4
COMMON LABOR	14264.08	+0.2	+3.9
WAGE $/HR.	27.10	+0.2	+3.9

BUILDING COST INDEX

Driven mostly by a 5.1% annual increase in its labor component, the BCI annual inflation rate rose from 1.5 to 1.9%.

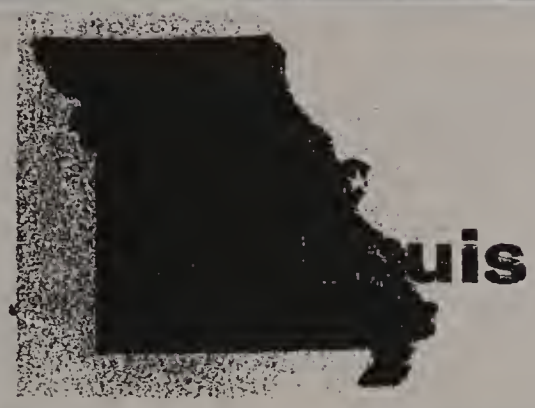
20-CITY: 1913=100	APRIL 2003 INDEX VALUE	% CHG. MONTH	% CHG. YEAR
BUILDING COST	3652.14	+0.1	+1.9
SKILLED LABOR	6421.44	+0.2	+5.1
WAGE $/HR.	35.64	+0.2	+5.1



MATERIALS COST INDEX

Modest increases in cement and steel prices could not overcome a decline in lumber prices.

20-CITY: 1913=100	APRIL 2003 INDEX/PRICE	% CHG. MONTH	% CHG. YEAR
MATERIALS	1959.90	–0.1	–3.9
CEMENT $/TON	83.07	+0.4	+1.4
STEEL $/CWT	25.71	+0.1	–4.8
LUMBER $/MBF	439.97	–0.3	–3.7



Dampening Effect

Falling lumber and steel prices have kept the annual escalation rate for the St. Louis indexes below the national average (see tables this page). Lumber prices tracked for St. Louis are down 14% from a year ago, while steel prices in the city's indexes are down 5%.

COST INDEXES BY CITY

1913=100 CITY	CONSTRUCTION COST APRIL '03 INDEX	CONSTRUCTION COST % CHG. YEAR	BUILDING COST APRIL '03 INDEX	BUILDING COST % CHG. YEAR	COMMON LABOR APRIL '03 INDEX	COMMON LABOR % CHG. YEAR	SKILLED LABOR APRIL '03 INDEX	SKILLED LABOR % CHG. YEAR	MATERIALS APRIL '03 INDEX	MATERIALS % CHG. YEAR
ATLANTA	4234.59	+4.8	2932.36	+0.3	8000.00	+9.2	4578.98	+4.2	1926.76	–5.0
BALTIMORE	4505.92	+1.2	3199.74	+3.5	9026.32	+3.2	5332.73	+8.5	1896.65	–4.1
BIRMINGHAM	4774.49	+0.6	2839.85	+1.2	9505.26	+2.2	4419.82	+5.1	1874.98	–3.9
BOSTON	7717.00	+1.1	4025.91	–0.2	17510.53	+2.7	7807.21	+2.7	1714.52	–7.5
CHICAGO	8285.51	+3.4	4272.24	+0.9	18363.16	+5.6	7812.01	+4.8	2108.89	–7.0
CINCINNATI	6273.70	+4.3	3320.17	+3.8	13352.63	+5.5	5587.39	+6.3	1935.00	–0.3
CLEVELAND	7049.38	+2.5	3657.41	+0.9	15265.79	+3.5	6347.75	+2.4	2013.52	–1.8
DALLAS	3883.15	+1.1	2709.61	+1.8	7057.89	+2.1	3974.77	+4.1	1937.34	–1.0
DENVER	4920.43	+1.9	3009.91	0.0	10002.63	+5.1	4981.38	+5.1	1805.53	–7.5
DETROIT	7636.31	+3.6	4124.13	+3.0	16715.79	+4.3	7482.88	+4.3	2071.47	+0.3
KANSAS CITY	6764.46	+4.7	3590.12	+2.5	14315.79	+6.5	5969.97	+5.6	2136.22	–2.4
LOS ANGELES	7556.93	+1.8	3872.45	+5.4	16565.79	+2.7	6878.68	+9.4	2035.37	–2.2
MINNEAPOLIS	7581.15	+3.8	3820.87	+2.2	16821.05	+5.4	6934.53	+5.4	1917.98	–4.2
NEW ORLEANS	3930.67	–0.6	2640.20	–0.4	7384.21	+1.5	3993.39	+3.8	1813.98	–5.5
NEW YORK	10286.25	+1.9	5407.40	+1.6	23986.84	+3.5	11162.16	+5.0	1889.12	–8.9
PHILADELPHIA	8208.52	+3.3	4514.39	+4.2	17736.84	+4.5	8025.83	+7.4	2368.58	–1.9
PITTSBURGH	6386.57	+1.8	3592.04	+0.6	13681.58	+3.7	6335.74	+3.9	1915.44	–5.5
ST. LOUIS	7153.87	+1.6	3574.50	+1.0	15973.68	+3.2	6562.76	+5.0	1748.18	–7.0
SAN FRANCISCO	7818.44	+2.0	4132.04	+3.1	17221.05	+2.8	7529.73	+5.3	2055.54	–1.7
SEATTLE	7642.47	+1.4	3807.40	+2.4	16794.74	+1.9	6711.11	+4.4	2033.02	–1.4
MONTREAL	6952.92	+1.3	3934.46	–0.1	14173.68	+3.7	6238.44	+4.2	2527.28	–6.0
TORONTO	8465.57	+4.4	4134.44	+1.0	18421.05	+5.8	7032.43	+2.6	2363.82	–1.8

SEWER, WATER AND DRAIN PIPE

ITEM	UNIT	ATLANTA	BALTIMORE	BIRMINGHAM	BOSTON	CHICAGO	CINCINNATI	CLEVELAND	DALLAS	DENVER	DETROIT	KANSAS CITY
REINFORCED CONCRETE PIPE (RCP) 12"	ft	8.56	15.85	8.45	–5.75	5.74	8.50	+8.00	–12.00	9.57	10.45	8.90
24"	ft	+20.53	27.50	21.97	–13.50	13.00	18.55	+18.00	–26.00	13.35	33.25	24.50
36"	ft	+34.78	50.80	35.24	29.30	27.00	36.40	+38.00	–52.75	40.10	68.10	38.00
48"	ft	52.30	+97.00	57.51	49.00	42.00	58.65	+60.00	–80.50	+61.20	102.40	66.00
CORRUGATED STEEL PIPE												
12"	ft	4.58	6.49	4.80	5.12	6.57	4.99	6.30	+5.80	+6.78	4.82	10.26
36"	ft	15.05	18.88	14.20	16.08	23.63	16.05	18.24	–18.25	+22.77	20.25	28.62
60"	ft	34.78	38.80	32.50	37.73	53.05	38.00	53.00	–51.00	+62.53	62.00	77.92
VITRIFIED CLAY PIPE (VCP) premium joint												
12"	ft	—	—	—	—	—	—	11.90	—	—	11.43	7.60
24"	ft	—	—	—	—	—	—	+62.30	—	—	38.56	33.39
POLYETHYLENE PIPE (PE), underdrain 4"	ft	0.52	—	0.32	0.48	0.79	0.34	0.27	+0.39	–0.55	0.23	—
POLYVINYLCHLORIDE PIPE (PVC), sewer												
4"	ft	1.11	+1.36	0.88	0.83	1.25	+0.78	0.82	0.85	–0.69	+1.72	0.90
8"	ft	+4.26	+3.81	3.01	2.59	2.61	+5.88	3.02	2.91	+2.87	+5.08	2.70
water 6"	ft	4.03	2.56	2.90	3.62	3.03	+4.23	3.85	3.56	+3.66	+6.07	2.20
8"	ft	5.80	4.10	4.54	6.62	5.23	+7.49	6.66	5.59	+5.88	+11.26	5.00
12"	ft	11.84	+5.58	8.87	14.22	11.20	+12.68	14.25	12.27	+11.13	+21.65	11.10
DUCTILE IRON PIPE (DIP) 6"	ft	–6.83	9.80	5.15	8.00	9.33	6.10	8.25	8.10	6.40	10.35	+5.20
8"	ft	–9.07	12.30	7.05	10.88	14.07	10.00	11.25	10.90	8.58	13.30	+7.15
12"	ft	–16.31	–20.75	12.15	17.97	+24.94	12.95	18.75	17.60	13.94	21.20	+12.00
COPPER WATER TUBING, type L 1/2"	ft	0.80	0.38	0.91	0.50	2.30	+0.74	0.66	0.54	+0.74	0.62	1.00
1 1/2"	ft	–2.80	1.48	3.55	1.94	2.70	+2.95	2.55	1.77	+2.45	2.41	3.89

+ or – denotes price has risen or fallen since previous report; a=meters, includes federal tax; b=meters, excludes tax; c=1.5 meters. Monthly market quotations by ENR field reporters April 4, 2003. All prices are spot prices quoted from a single source. Quotes are delivered prices unless noted. Some prices may include taxes or discounts for prompt payment, etc. Product specification may vary, depending on what is most commonly used or most accessible in a city. All quantities are truckloads unless noted. Quotes for Montreal and Toronto are in Canadian dollars and metric units. RCP pipe is ASTM C76; 12-in. and 24-in. are rubber-gasket jointed, others are nongasketed. Corrugated steel pipe is plain galvanized; 12-in. is 16-gauge, 36-in. is 14-gauge, 60-in. is *(continued on p. 20)*

For a complete history of cost indexes, visit our Website, enr.com.

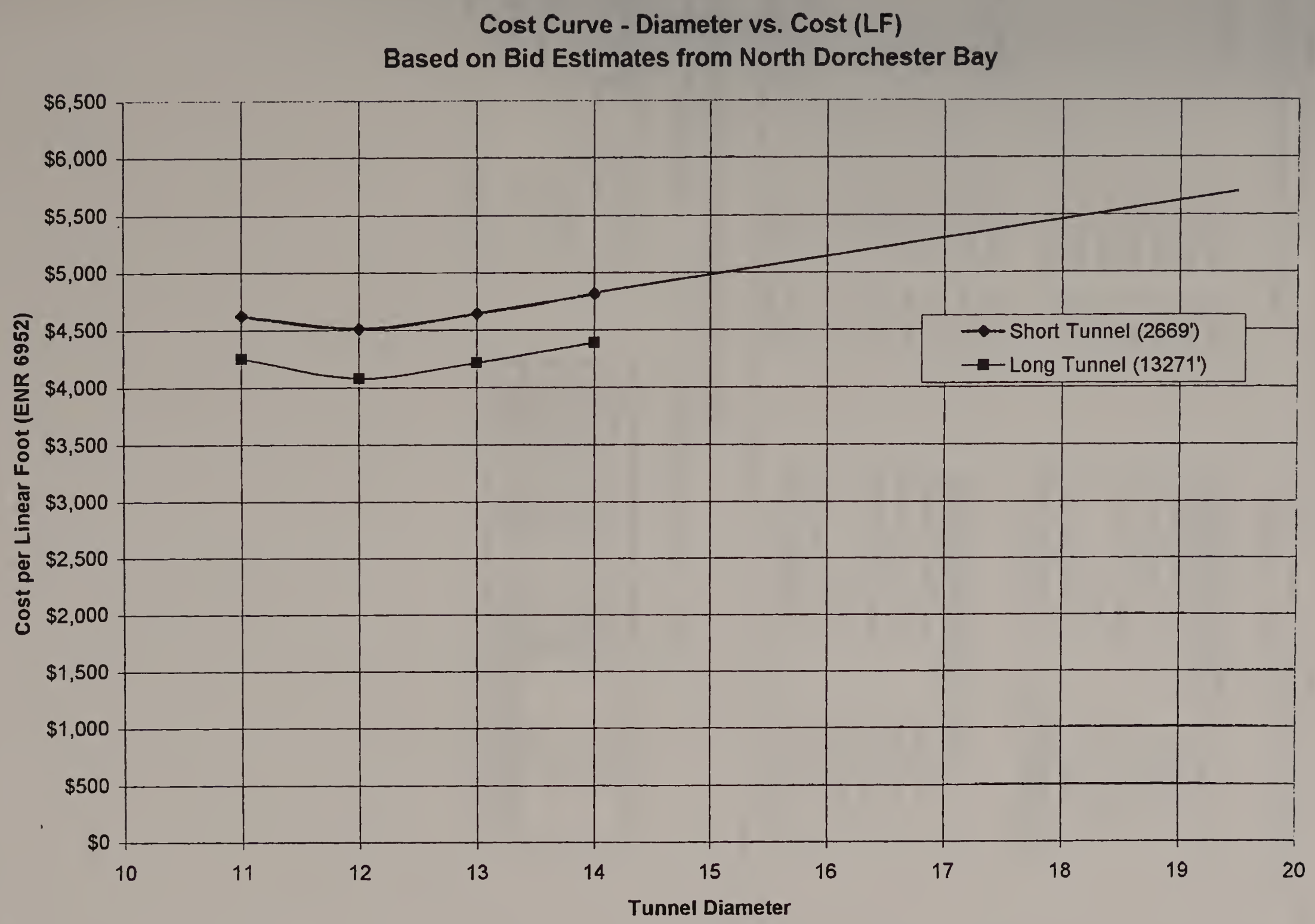
Conduit Unit Costs

Costs taken from NDB Construction Bid Estimates (Calculated by R. Roberts (PB) Feb/Mar, 1999)

Unit Costs for various diameters:

	11' DIAM		12' DIAM		13' DIAM		14' DIAM	
	Linear Ft.	Unit Cost	Linear Ft.	Unit Cost	Linear Ft.	Unit Cost	Linear Ft.	Unit Cost
Tunnel #1	13271	4247.04	13271	4075.08	13271	4211.17	13271	4385.26
Tunnel #2	2669	4615.64	2669	4501.48	2669	4636.25	2669	4804.88

Diam	Short	Long
11	4615.64	4247.04
12	4501.48	4075.08
13	4636.25	4211.17
14	4804.88	4385.26


Cost Curve - Diameter vs. Cost (LF)
Based on Bid Estimates from North Dorchester Bay
$6,500
$6,000
$5,500
$5,000
$4,500
$4,000
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
Cost per Linear Foot (ENR 6952)
10
11
12
13
14
15
16
17
18
19
20
Tunnel Diameter
Short Tunnel (2669')
Long Tunnel (13271')

Microtunnel Cost Curve Development

From Bryant Associates, Inc.

Chelsea Branch Sewer Relief Project - 3/1/99

Orig. Prepared by: H. Goldberg/D. Grotenhuis

Boston Index: **6747**

Jacking Shaft No.	1	$200,000	*for 66"*
	2	$200,000	*for 66"*
	3	$120,000	*for 66"*
	4	$160,000	*for 36"*
	5	$160,000	*for 36"*
	6	$160,000	*for 36"*
	7	$150,000	*for 36"*
Receiving Shaft No.	1	$265,000	*for 66"*
	2	$290,000	*for 66"*
	3	$295,000	*for 66"*
	4	$100,000	*for 36"*
	5	$175,000	*for 36"*
	6	$240,000	*for 36"*
Microtunneling - 36		$1,000	*per LF*
Microtunneling - 66		$1,500	*per LF*

66" Microtunnel	(5.5 ft diam)
Jacking Shaft Cost:	$520,000
Receiving Shaft Cost	$850,000
3365' of 66" Tunnel	$5,047,500
SUM	$6,417,500
Adj. Cost (per L.F.)	$1,907
35% Adjustment	**$2,575**

36" Microtunnel	(3 ft diam)
Jacking Shaft Cost:	$630,000
Receiving Shaft Cost	$515,000
4130' of 66" Tunnel	$4,130,000
SUM	$5,275,000
Adj. Cost (per L.F.)	$1,277
35% Adjustment	**$1,724**

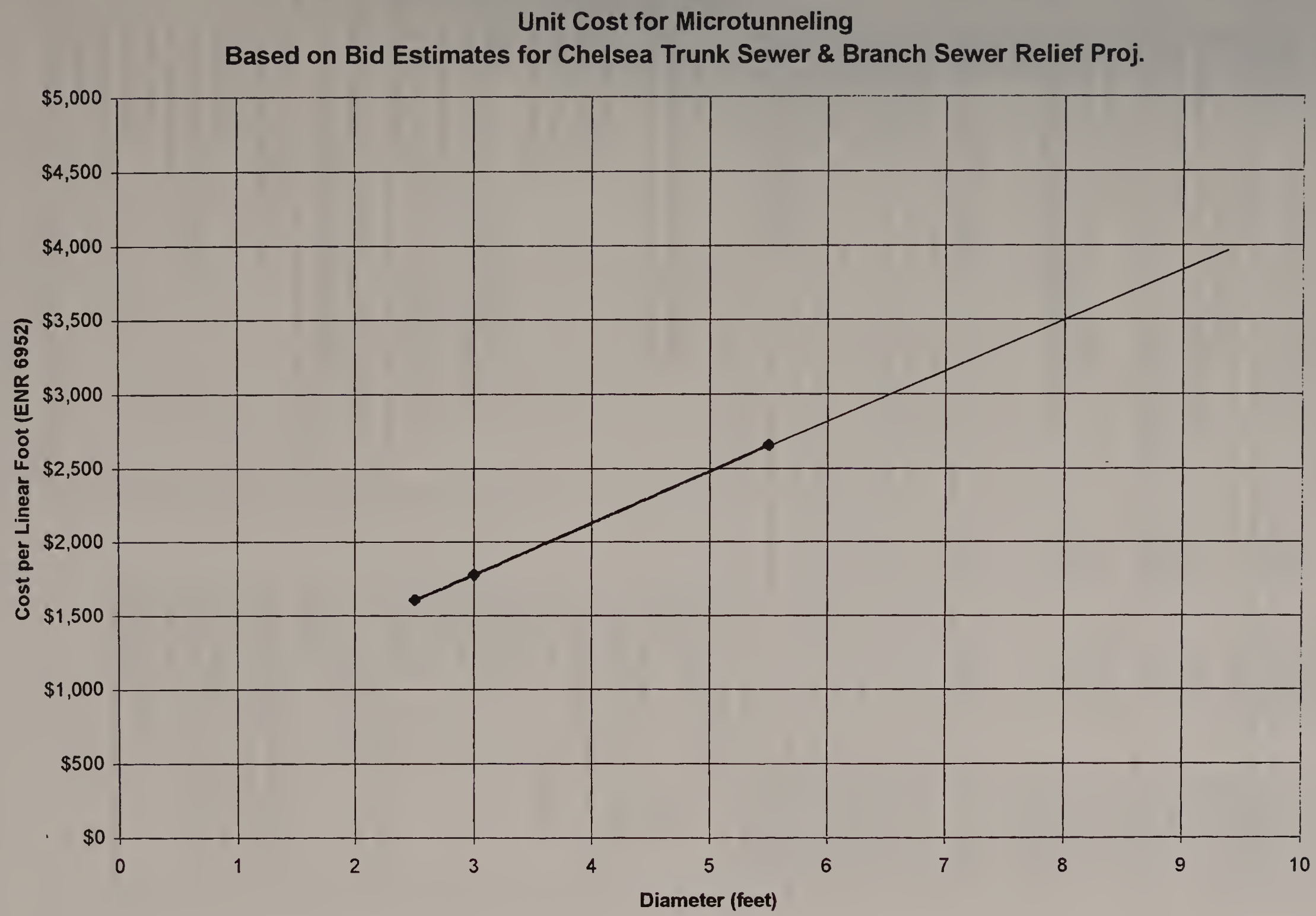
From Metcalf and Eddy (MWRA Contract 6262)

Chelsea Trunk Sewer Relief Project

Tablulation of Bids Rec'd: 6/29/99

30" Microtunnel	(2.5 ft diam)
Tabulation of Bids Rec'd:	6/29/99
Average of Bids - LF	**$1,558**
Engineers Estimate - LF	$1,155
Percent Difference	$0
ENR used	6747

Diam	Unit Cost	Unit Cost	ENR
5.5	$2,653	$2,575	6747
3	$1,776	$1,724	6747
2.5	$1,605	$1,558	6747
ENR:	6952	BASE USED FOR PROJECT	


Unit Cost for Microtunneling
Based on Bid Estimates for Chelsea Trunk Sewer & Branch Sewer Relief Proj.
Cost per Linear Foot (ENR 6952)
$5,000
$4,500
$4,000
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
0
1
2
3
4
5
6
7
8
9
10
Diameter (feet)

CONSOLIDATION STORAGE OPTION
NO SEPARATION - 0 DISCHARGES PER YEAR
17.0' DIAMETER

ITEM	DESCRIPTION	UNITS	BID UNITS	BID AMOUNT
1	**MINING SHAFT w/BACKFILL 30' DIAM**	1	**$718,675.54**	**$718,675.54**
2	**CONSTRUCTION ACCESS SHAFT w/BACKFILL 30' DIAM**	1	**$494,154.42**	**$494,154.42**
3	**EPBM TUNNEL w/PCS LINING** *Depends on diam of tunnel	4455	**$5,250.00**	**$23,388,750.00**
4	**DROP SHAFT**	4	**$173,572.22**	**$694,288.88**
5	**DIVERSION STRUCTURE**	6	**$214,953.42**	**$1,289,720.52**
6	**REMOVAL OF CONTAMINATED SOILS**			**$19,363,857.98**
	Characterization ($1790/sample - 1 sample/500 cy execv.)	2142	$1,790.00	$3,834,215.24
	Waste soil hauling ($56/cy)	267752	$56.00	$14,994,137.81
	Contaminated Groundwater Treatment $0.50/cubic foot excev.	1071010	$0.50	$535,504.92
7	**ODOR CONTROL FACILITY**			**$732,316.28**
	Calgon odor control unit(s)	2	$354,300.00	$567,706.28
	Odor control facility - Outdoor Area (Tmt. Units)	2000	$146.00	$292,000.00
	Odor control facility - Indoor Area (Elec. Components)	600	$274.35	$164,610.00
8	**CONDUIT DEWATERING PUMPS**			**$300,000.00**
	Pumps			$150,000.00
	VFD's			$150,000.00
9	**OTHER COSTS** *See Below (per L.F.)	4455	**$230.00**	**$1,024,650.00**

SUBTOTAL 1	$48,006,413.62
7.5% Mobilization	$3,600,481.02
SUBTOTAL 2	$51,606,894.64
Contingency - 25%	$12,901,723.66
SUBTOTAL 3	$64,508,618.30
Engineering - 20%	$12,901,723.66
GRAND TOTAL (ENR 6952)	**$77,410,341.96**
GRAND TOTAL (ENR 6225)	**$69,315,215.58**

NOTES

1071010	Total Volume of excavated soil - Cubic Yards
25%	Percentage of excavated soil that is contaminated
267752	Total Volume of contaminated soil - Cubic Yards
4455	Conduit Length (ft)
17.5	Conduit Diameter (ft)
1071010	Conduit Volume (ft^3)
8.01	Conduit Volume (Mgal)
453.46	Peak Flow (cfs) - Water *in* (assume equals air *out*)
283	Max flow rate through O/C - MANUF. SPECIFICATION
2	Number of required Units
1300	Area required per unit (sq ft) - 1000 (unit), 300 (electrical)
2083	Total Area Required

Note: Developed from NDB Estimates - 1/99, 2/99, 3/99
Average Boston **ENR** for that 3 mo. period = **6952**

* Other Costs Include:
- Grout at Tunnel and Shaft Junctions
- Instrumentation
- Relocate Utilities
- Pre-Construction Survey OF Structures
- Leak Mitigation Survey
- Traffic Control
- Site Restoration
- Disputes Review Board
- Obstructions
- Noisewall

Design Storm Information
#43 - 9/22/1992

Duration:	22.2 hrs.
Total Rain Depth:	2.79 in.
Avg. Intensity:	0.13 in./hr.

Activated Outfalls

ID Number	Volume (MG)
CAM 002	
CAM 004-CS	
CAM 004-SD	
CAM 400	
CAM 401	
CAM 401B	
SOM 001A	

Not Activated
CAM 001
MWR 003

Total CSO Volume 7.71

Drop Shaft Array
CAM 004-CS, CAM-004-SD, CAM 401
CAM 400
CAM 401B, CAM 002
SOM 001A

CONSOLIDATION - CONDUIT TO TREATMENT
NO SEPARATION 0 - DISCHARGES PER YEAR
7.0' DIAMETER MICROTUNNEL AND TREATMENT COSTS

Design Storm Information	
#43 - 9/22/1992	
Duration:	22.2 hrs.
Total Rain Depth:	2.79 in.
Avg. Intensity:	0.13 in./hr.

Outfall	Regulator	Overflow Conduit #	Peak Flow (cfs)	Volume (MG)
CAM 001	RE-011	7104	0	
CAM 002	RE-021(H)	7114	12.88	
CAM 003	RE-031	7124	0	
CAM 004	RE-041 (CS)	7154	2.12	
CAM 004	SD	7992	35.23	
CAM 400	RE-400	7120	4.16	
CAM 401	RE-401	7170	28.54	
CAM 401B		7402	16.39	
SOM 001A	RE-01A	6152	81.97	
		SUM	**181.29**	**7.71**

Design Flow	181.29	cfs
	1,356	gps
	117,162,651	gpd
with 0.9 Multipl.	**105,446,386**	gpd
Conduit Vol	160,822	ft^3
Total Storage Vol.	1,202,950	gal
Volume to Treat	**6,507,050**	

Tunnel Diameter:
D = [Q/1.14]^(3/8)

Diameter (ft)	**6.69**	**7.0**
Length (ft)	**4181**	

Note: Flows from CAM004/401 Not included in conduit diameter calculations.

Disinfection/Tmt.	Cost	ENR
	$12,750,000	6225
	$14,239,036	6952
BASED ON Q of	*105,446,386*	*gpd*

Disinfection/Tmt.	
SUBTOTAL 1	$8,500,000
Contingency 25%	$2,125,000
SUBTOTAL 2	$10,625,000
Engineering 20%	$2,125,000
TOTAL	**$12,750,000**

TOTAL COSTS	
Conduit	$31,794,193
Disinfection/Tmt.	$14,239,036
TOTAL (6952)	**$46,033,229**
TOTAL (6225)	**$41,219,340**

CONSOLIDATION - CONDUIT TO TREATMENT
7.0' DIAMETER MICROTUNNEL COSTS

ITEM	DESCRIPTION	UNITS	BID UNITS	BID AMOUNT
1	**MICROTUNNEL - W/JACKING AND RECEIVING TUNNEL**	**4181**	**$3,150.00**	**$13,170,150.00**
2	**DIVERSION STRUCTURE**	**7**	**$214,953.42**	**$1,504,673.94**
3	**REMOVAL OF CONTAMINATED SOILS**			**$2,907,664.74**
	Characterization ($1790/sample - 1 sample/500 cy execv.)	322	$1,790.00	$575,743.35
	Waste soil hauling ($56/cy)	40206	$56.00	$2,251,510.31
	Contaminated Groundwater Treatment $0.50/cubic foot excev.	160822	$0.50	$80,411.08
4	**ODOR CONTROL FACILITY**			**$873,210.00**
	Calgon odor control unit(s)	2	$354,300.00	$708,600.00
	Odor control facility - Outdoor Area (Tmt. Units)	2000	$146.00	$292,000.00
	Odor control facility - Indoor Area (Elec. Components)	600	$274.35	$164,610.00
5	**CONDUIT DEWATERING PUMPS**			**$300,000.00**
	Pumps			$150,000.00
	VFD's			$150,000.00
6	**OTHER COSTS** *See Below **(per L.F.)**	4181	**$230.00**	**$961,630.00**

SUBTOTAL 1	$19,717,328.68
7.5% Mobilization	$1,478,799.65
SUBTOTAL 2	$21,196,128.33
Contingency - 25%	$5,299,032.08
SUBTOTAL 3	$26,495,160.42
Engineering - 20%	$5,299,032.08
GRAND TOTAL (ENR 6952)	**$31,794,192.50**
GRAND TOTAL (ENR 6225)	**$28,469,339.52**

NOTES

160822	Total Volume of excavated soil - Cubic Yards
25%	Percentage of excavated soil that is contaminated
40206	Total Volume of contaminated soil - Cubic Yards
4181	Conduit Length (ft)
7	Conduit Diameter (ft)
160822	Conduit Volume (ft^3)
1.2	Conduit Volume (Mgal)
331	Peak Flow (cfs) - Water *in* (assume equals air *out*)
283	Max flow rate through O/C - MANUF. SPECIFICATION
2	Number of required Units
1300	Area required per unit (sq ft) - 1000 (unit), 300 (electrical)
2600	Total Area Required

Note: Developed from NDB Estimates - 1/99, 2/99, 3/99
Average Boston **ENR** for that 3 mo. period = **6952**

* Other Costs Include:
- Grout at Tunnel and Shaft Junctions
- Instrumentation
- Relocate Utilities
- Pre-Construction Survey OF Structures
- Leak Mitigation Survey
- Traffic Control
- Site Restoration
- Disputes Review Board
- Obstructions
- Noisewall

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
5.5' DIAMETER MICROTUNNEL AND TANK COSTS

Outfall	Regulator	Overflow Conduit #	1-year Peak Flow
CAM 001	RE-011	7104	0
CAM 002	RE-021(H)	7114	14.64
	RE-021 (L)	7110	CLOSED
CAM 003	RE-031	7124	0
CAM 004	RE-041 (CS)	7154	4.34
CAM 004	SD	7992	34.68
CAM 400	RE-400	7120	5.12
CAM 401	RE-401	7170	21.92
CAM 401B		7402	17.1
SOM 001A	RE-01A	6152	70.76

Storm Volume
7.71 MG

5.0' Diameter Tunnel	$25,252,220
Storage Tank	$57,943,258
TOTAL COSTS	$83,195,478 (ENR 6952)
TOTAL COSTS	$74,495,375 (ENR 6225)

Sum of Flows for Regulators Active during design storm
107.62 **cfs**

Diameter Calculations: NOTE - Flows from CAM004-SD, CAM004-CS and CAM401 were not used - conduit will not pick up flows from these regulators. Seperately conveyed to tank.

Diameter = [Q/1.14]^(3/8)

Diameter (ft) **5.50** **5.5**

Since Diameter is in range for microtunnel technology, length can be shortened to 4181 ft. since it is not necessary to extend conduit past SOM 001A to large "parkland" to allow for construction equpiment removal shaft.

Calculating Conduit Volume:

99283	ft^3
0.74	MG

Therefore, required tank volume is difference between design storm volume and conduit volume

7.71	**Storm Vol (MG)**
0.74	**Conduit Vol (MG)**
6.97	**Required Tank Volume (MG)**
931390	**Required Tank Volume (ft^3)**

15	**Depth (ft)**
62093	Area to Size (ft^2)

Assuming L:W ratio of 2:1

176	**Length (ft)**
352	**Width (ft)**

Note: Tank Dimensions above are dimensions required to hold design volume. Actual tank size/footprint is much large to account for wall thickness and construction material.

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
5.5' DIAMETER MICROTUNNEL

ITEM	DESCRIPTION	UNITS	BID UNITS	BID AMOUNT
1	**MICROTUNNEL - W/JACKING AND RECEIVING TUNNEL**	**4181**	**$2,600.00**	**$10,870,600.00**
2	**DIVERSION STRUCTURE**	**4**	**$214,953.42**	**$859,813.68**
3	**REMOVAL OF CONTAMINATED SOILS**			**$1,795,037.93**
	Characterization ($1790/sample - 1 sample/500 cy execv.)	199	$1,790.00	$355,433.40
	Waste soil hauling ($56/cy)	24821	$56.00	$1,389,963.00
	Contaminated Groundwater Treatment $0.50/cubic foot excev.	99283	$0.50	$49,641.54
4	**ODOR CONTROL FACILITY**			**$873,210.00**
	Calgon odor control unit(s)	2	$354,300.00	$708,600.00
	Odor control facility - Outdoor Area (Tmt. Units)	2000	$146.00	$292,000.00
	Odor control facility - Indoor Area (Elec. Components)	600	$274.35	$164,610.00
5	**CONDUIT DEWATERING PUMPS**			**$300,000.00**
	Pumps			$150,000.00
	VFD's			$150,000.00
6	**OTHER COSTS** *See Below **(per L.F.)**	4181	**$230.00**	**$961,630.00**

SUBTOTAL 1	$15,660,291.61
7.5% Mobilization	$1,174,521.87
SUBTOTAL 2	$16,834,813.48
Contingency - 25%	$4,208,703.37
SUBTOTAL 3	$21,043,516.85
Engineering - 20%	$4,208,703.37
GRAND TOTAL (ENR 6952)	**$25,252,220.22**
GRAND TOTAL (ENR 6225)	**$22,611,488.90**

NOTES

99283	Total Volume of excavated soil - Cubic Yards
25%	Percentage of excavated soil that is contaminated
24821	Total Volume of contaminated soil - Cubic Yards
4181	Conduit Length (ft)
5.5	Conduit Diameter (ft)
99283	Conduit Volume (ft^3)
0.7	Conduit Volume (Mgal)
331	Peak Flow (cfs) - Water *in* (assume equals air *out*)
283	Max flow rate through O/C - MANUF. SPECIFICATION
2	Number of required Units
1300	Area required per unit (sq ft) - 1000 (unit), 300 (electrical)
2600	Total Area Required

Note: Developed from NDB Estimates - 1/99, 2/99, 3/99
Average Boston **ENR** for that 3 mo. period = **6952**

* Other Costs Include:
- Grout at Tunnel and Shaft Junctions
- Instrumentation
- Relocate Utilities
- Pre-Construction Survey OF Structures
- Leak Mitigation Survey
- Traffic Control
- Site Restoration
- Disputes Review Board
- Obstructions
- Noisewall

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - INPUT SHEET

"Project" Inputs

**These inputs will remain constant for each tank option in a given location

Input	Value	Units
Slurry Wall Unit Cost	$ 83.90	
Slurry Wall Unit Cost ENR Cost Index	6,497	
ENR Cost Index for This Project	6,952.0	
Slurry Wall Width/Length outside of Structure	5.0	ft.
Slurry Wall depth Below Bottom of Structure	15.0	ft.
Excavate Disposal Unit Cost	$ 25.00	
Excavate Disposal Unit Cost ENR Cost Index	6,497	
Soil Density	1.5	tons/cy
Percentage of Excavated Soil to be Disposed	50%	
Cost for Inter-facility Controls, Stand-by Power (allow.)	$ 100,000	
Cost for Connecting Pipeline	$ 100,000	
Cost for Site Restoration/Mitigation	$ 1,140,044	

"Tank-Specific" Inputs

**These inputs will vary for each design alternative

Input	Value	Units
Max Depth of CSO Storage	15	ft.
Interior Length of Storage Bays	352	ft.
Volume of CSO to be Stored	6.97	MG
Slenderness Ratio of Storage Bays	5	
Storage Bay Width - End wall thickness	3.0	ft.
Storage Bay Width - Interior wall thickness	1.5	ft.
Storage Bay Length - End wall thickness	3.0	ft.
Storage Bay Length - Influent Channel Length	10	ft.
Storage Bay Length - Interior wall thickness	1.5	ft.
Storage Bay Length - # of Interior walls	1	each
Depth of Excavation	40	ft.
# of Air Changes per Hour	5	each
Odor Control Facility Indoor Area	3000	SF
Odor Control Facility Outdoor Area	10000	SF
Distance from Max. Water Surface to Roof Slab	10	ft.

OUTPUTS

**Number of Fans Required in O.C. Facility - Use this for square footage requirements	10	
Number of Storage Bays	3	
Overall Structure Width	220	ft.
Overall Structure Length	370	ft.

TOTAL COST OF CONSTRUCTION $ 38,628,838

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - TANK SIZING

Storage Tank Calculations

Note: User inputs will appear in bold.

Depth of CSO Storage:	**15**	feet
Interior Length of Storage Bay:	**352.39934**	feet
Volume of CSO to be stored:	**6.967308**	MG
Volume =	931458.28	cubic feet
"Width" of Storage required:	176.2	feet

Find # of Bays required:

Slenderness Ratio for Bays:	**5**	:1
Bay width =	70.479869	feet
End wall thickness:	**3.0**	feet
Interior wall thickness:	**1.5**	feet
Number of Bays:	2.500184	bays
Rounding up, use # of bays:	3	bays
Total width, exterior walls:	6	feet
# of interior Walls:	2	each
Total width, interior walls:	3	feet
Total width, bays:	211.43961	feet

Total width of Storage Structure: 220.44 feet

Outside Dimensions of Storage Tank:

Width:	220.43961	feet
Length of Bays:	352.39934	feet
Exterior Wall Thickness:	**3**	feet
Length of Influent Channel:	**10**	feet
Interior Wall Thickness:	**1.5**	feet
# of interior Walls:	**1**	each

Total Length of Structure: 369.899 feet

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - SLURRY WALL

Slurry Wall Calculations

Unit Cost for Slurry Wall:	$	83.90	/sq ft at ENR=	6497
ENR Cost index for Project:		6952		
Project Unit Cost for Slurry Wall:	$	89.78	/sq ft	

Slurry wall width/length =	5	ft outside of structure perimeter
Slurry wall depth =	15	ft below bottom of excavation

Exterior Dimensions of Structure:

Length:	369.8993433	feet
Width:	220.439606	feet
Depth of Excavation:	40	feet
Slurry Wall Perimeter =	1220.677899	feet
Slurry Wall Height =	55	feet
Total Slurry Wall Area =	67137.28442	square feet
Total Slurry Wall Cost =	$ 6,027,298	

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - ODOR CONTROL FACILITY

Odor Control Facility Calculations

# Air Changes per Hour:	5	each

Volume of Empty Tank:

# of Bays	3	each
Bay Width:	70.47986866	ft.
Bay Length:	352.3993433	ft.
Depth of CSO Storage:	15	ft.
Height, Max. WS to Roof slab:	10	ft.
Total Volume of Tank =	1,862,779	cubic feet
CFM Rate:	155,232	CFM
Capacity per Fan Unit:	17,000	CFM
Total Fans Needed:	9.13127185	units
Round-up:	10	units

Unit Prices for Odor Control Costing:

$/SF, Indoor Area	$	274.35
$/SF, Outdoor Area	$	146.00
$/each, Odor Control/Fan Unit	$	354,300

Total Indoor Area	3000	SF
Total Outdoor Area	10000	SF

Cost of Indoor Area:	$	823,050
Cost of Outdoor Area:	$	1,460,000
Cost of Odor Control/Fan Units:	$	3,543,000
Total Cost	$	5,826,050
For Site Work, add:		8%
Total Cost Including Site Work	$	6,292,134
Based on Boston ENR Cost Index:		6938
ENR Cost Index for this project:		6952

TOTAL COST, ODOR CONTROL FACILITY: $ 6,304,831

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - EXCAVATION COSTS

Excavate Disposal Calculations

Unit Cost for Excavate Disposal:	$	**25.00**	/ton at ENR=	**6497**
ENR Cost index for Project:		6952		
Project Unit Cost for Exc Disposal:	$	26.75	/ton	
Soil Density:		**1.5**	tons/cy	
Project Unit Cost for Exc Disposal:	$	40.13	/cy	

Volume of Soil to be Disposed:

% of excavated soil to be disposed:	**50%**	
Length of Structure:	369.8993433	feet
Width of Structure:	220.439606	feet
Depth of Excavation:	40	feet
Soil Volume to be Disposed =	60,400	cy
Disposal Cost =	$ 2,423,637	

CONSOLIDATION TO STORAGE TANK
NO SEPARATION - 0 DISCHARGES PER YEAR
TANK COSTS - TOTAL COSTS

Total Construction Cost Calculations

Cost Curve for this Facility

***This cost includes Excavation, Backfill, Concrete work, and mechanical & electrical equipment

Water Volume to be stored		6.97	MG
Total Cost	$	18,076,527	
Based on ENR Cost Index =		4800	
ENR National Cost Index, 3/94 =		5405	
ENR Boston Cost Index, 3/94 =		6280	
Project ENR Cost Index =		6952	
Adjusted Construction Cost =	$	22,533,029	

Additional Costs

Allowance - Inter-facility controls, Stand-by Power	$	100,000
Connecting Pipeline (total cost)	$	100,000
Site Restoration/Mitigation	$	1,140,044

Summarized Costs

Slurry Wall	$	6,027,298
Disposal of Excavate	$	2,423,637
Odor Control	$	6,304,831
SUBTOTAL1		$38,628,838
Contingency 25%		$9,657,210
SUBTOTAL 2		$48,286,048
Engineering 20%		$9,657,210
GRAND TOTAL		**$57,943,258**

Appendix G

APPENDIX G

AFFORDABILITY WORKSHEETS

Attachment A
Boston MA—Assessment of Substantial Impacts

Introduction

The MWRA projects that the average household in the MWRA service area will pay $463 for wastewater service in fiscal year (FY) 2010, which begins in calendar year (CY) 2009. In the same year, the projected cost for wastewater and water service is estimated to be $783 per household. These estimates are based on average household consumption of 61,000 gallons per year (based on actual water consumption as reported to the Massachusetts Department of Environmental Protection). When costs are projected based on the AWWA standard of 90,000 gallons per year, the average household would pay $684 for sewer service and $472 for water service. Combined water and wastewater service costs would be $1,155.

The estimated household costs for both water and wastewater service in Boston are slightly lower than the average MWRA rate for the service area. The MWRA projects that the average household in Boston will pay $397 for wastewater service alone, and $560 for water and wastewater service combined, at a usage rate of 61,000 gallons per year. These costs climb to $696 and $855, respectively, at usage of 90,000 gallons per year.

Preliminary Municipal Screener

The purpose of the Preliminary Municipal Screener is to assess whether there is a potential for impacts of proposed pollution control projects to be substantial. The municipal screener determines the average cost of proposed pollution control measures as a percentage of median household income (MHI).

In Boston, MHI in 1999 (2000 census) was $39,629. This can be escalated to FY 2001 through use of the consumer price index for the Boston Metropolitan Area, and then estimated to the planning period year of 2009 by escalating at a rate of 2.5 percent per year. These calculations result in an estimate of CY 2009 MHI of $52,592 for the city of Boston.

The projected average cost of wastewater service per household ($397) as a percentage of MHI in CY 2009 ($52,592) is therefore 0.008, or approximately 1.0 percent based on usage of 61,000 gallons per year. The projected CY 2009 combined cost of water and wastewater service ($560) would be 1.1 percent of MHI. At the increased usage of 90,000 gallons per year, wastewater costs as a percentage of MHI climb to 1.2 percent, and combined water and wastewater costs climb to 1.6 percent of MHI.

Secondary Test

The purpose of the secondary test is to assess the financial health of a community. Six different financial indicators are used. These include Bond Rating, Overall Net Debt as a Percent of Full Market Value of Taxable Property, Unemployment, Median Household Income, Property Tax Revenues as Percent of Full Market Value (FMV) of Taxable Property, and Property Tax Collection Rate. Of these six factors, two have had to be modified in Massachusetts because of Proposition 2 ½ which limits the amount of property tax revenue a community can assess and collect. For this reason, the factor evaluating overall net dept as a percent of FMV of taxable property has been changed to overall net debt per capita, and the factor evaluating property tax revenues as a percent of FMV has been eliminated. Thus, only five factors have been used to

assess the financial health of the city of Boston (see attached worksheets E and F from the EPA Guidance).

Each of the five factors is assigned a score from 1-3, with 1 representing economic weakness and 3 representing economic strength. The scores are then averaged to provide an overall score. For the city of Boston, the five factors and the ratings are as follows.

Bond Rating: Boston's bond rating in FY 2002 was Aa2 (Moody's). An Aa2 rating is considered a strong indicator and is assigned three points.

Debt Per Capita: Boston's debt per capita in FY 2002 was approximately $1,113. Per capita debt of between $1,000 and $3,000 is considered mid-range and is assigned two points.

Unemployment: Boston's unemployment rate in FY 2002 was 5.3, below the national average at the same time period of 5.8. An unemployment rate below the national average is considered to represent a strong condition and is assigned three points.

Median Household Income: Boston's MHI in the 2000 census was $39,629 compared to the state median of $50,502. Thus the indicator would represent a weak condition and is assigned one point.

Property Tax Collection Rate: Boston's property tax collection rate in FY 2002 was approximately 97 percent. This is considered a mid-range condition and is assigned two points.

Total Secondary Score: Boston's average score would be 2.2, indicating that the city falls in the mid-range category for financial health.

Evaluating Substantial Impact

EPA's Economic Guidance for Water Quality Standards provides a matrix, shown below, which integrates the results of the preliminary municipal screener and the secondary score. Based on a municipal screener of approximately 1.0 (wastewater costs alone), or 1.1 (wastewater and water costs combined), and a secondary score of 2.2, at average usage of 61,000 gallons per year per household, Boston would fall in the middle cell of the middle column, indicating that the impact is unclear, but could be potentially substantial. These numbers are confirmed at the higher usage rate of 90,000 gallons per year per household.

Secondary Score	Municipal Preliminary Screener		
	Less than 1.0 Percent	Between 1.0 and 2.0 Percent	Greater than 2.0 Percent
Less than 1.5	?	X	X
Between 1.5 and 2.5	√	?	X
Greater than 2.5	√	√	?

Further Information to Support Determination of Widespread Impact

Labor Force and Unemployment. As reported by the Massachusetts Division of Employment and Training, the 2002 annual unemployment rate for Boston (5.8 percent) was higher than the rate for Massachusetts as a whole (5.3 percent).

Housing. The city of Boston has the third highest percentage of subsidized housing units in the state with 19.6 percent of the housing stock classified as subsidized. The city is ranked only behind Aquinnah (21.9 percent) and Holyoke (20.6 percent). According to the Department of Housing and Community Development, Boston had a total of 14,265 public housing units in the year 1999. In 1999, the city had an additional 1,050 mobile (tenant-based) Massachusetts Rental Vouchers and 9,657 Federal Section 8 vouchers.

Education. According to the 2000 U.S. Census, 78.9 percent of the population of Boston over the age of 25 are high school graduates, including high school equivalency. In the state of Massachusetts, 84.4 percent of residents over the age of 25 have attained high school graduation or equivalency. While Boston falls below the state's percent of high school graduates, the percentage of Boston's population over the age of 25 with a bachelor degree or higher is slightly higher than Massachusetts as a whole (35.6 percent and 33.2 percent, respectively).

Income. The median household income for Boston as reported in the 2000 Census was $39,629, which is 78.5 percent of the state median of $50,502. The median family income of $44,151 in Boston is less than three-fourths of the state median family income of $61,644. Federal guidelines define the poverty level for 2000 for a family of four as approximately $17,050 per year. According to the 2000 Census, 15.3 percent of Boston families live below the poverty line. In contrast, 6.7 percent of Massachusetts families live below the poverty line.

Health Characteristics. In 2001, Boston's teen birth rate was greater than the rate for Massachusetts, with 8.7 percent of pregnancies in women under 20 years of age, and 3.1 percent of pregnancies in women less than 18 years old. The state average teen birth rates are significantly lower than Boston's, with 6.2 percent in women under 20 years old and 2.1 percent in women under 18 years of age.

State Aid. Based on estimates from the Department of Revenue, Boston's state aid for FY 2003 is 1.9 percent less than state aid received for FY 2002 ($559 million and $570 million, respectively).

In summary, although EPA's Economic Guidance for Water Quality Standards matrix indicates that substantial impact as a result of the implementation of the recommended plan for CSO control is unclear, the information presented above illustrates the fact that Boston is currently experiencing economic stress. Thus, implementation of the CSO control projects would result in substantial and widespread social and economic impacts on the residents of the city.

Worksheet E

Boston

Data Used in the Secondary Test

Please list the following values used in determining the Secondary Score. Potential sources of the data are indicated.

FY02 unless noted otherwise

A. Data Collection

Data	Potential Source	Value	
Direct Net Debt	Community Financial Statements Town, County or State Assessor's Office	$ 655,797,474	(1)
Overlapping Debt	Community Financial Statements Town, County or State Assesor's Office	$ ---	(2)
Market Value of Property	Community Financial Statements Town, County or State Assessor's Office	$ 54,189,508,000	(3)
Bond Rating	Standard and Poors or Moody's	Aaz (Moody's)	(4)
Community Unemployment Rate	2000 Census of Population Regional Data Centers	5.4	%(5)
National Unemployment Rate	Bureau of Labor Statistics (202) 606-6392	5.8	(6)
Community Median Household Income	2000 Census of Population	$ 39629	*
State Median Household Income	2000 Census of Population	$ 50,502	(8)
Property Tax Collection Rate	Community Financial Statements Town, County or State Assessor's Office	97%	(9)
Property Tax Revenues	Community Financial Statements Town, County or State Assessor's Office	$ 972,234,000	(10)

2000 population - 589,141

Wo' eet F

Calculating The Secondary Score

Boston

Please check the appropriate box in each row, and record the corresponding score in the final column. Then, sum the scores and compute the average. Remember, if one of the debt or socioeconomic indicators is not available, average the two financial management indicators and use this averaged value as a single indicator with the remaining indicators.

	Secondary Indicators			Score
Indicator	Weak*	Mid-Range**	Strong***	
Bond Rating Worksheet E, (4)	Below BBB (S&P) Below Baa (Moody's) ☐	BBB (S&P) Baa (Moody's) ☐	Above BBB (S&P) or Baa (Moody's) XX	3
Overall Net Debt Per Capita	Above $3,000 ☐	$1,000-$3,000 XX	Below $1,000 ☐	2
Unemployment Worksheet E, (5)& (6)	Above National Average ☐	National Average ☐	Below National Average XX	3
Median Household Income Worksheet E, (7) & (8)	Below State Median XX	State Median ☐	Above State Median ☐	1
Property Tax Revenues as a Percent of Full Market Value of Taxable Property Worksheet E, (13)	Above 4% ☐	2%-4% ☐	Below 2% ☐	N/A
Property Tax Collection Rate Worksheet E, (9)	< 94% ☐	94% - 98% XX	> 98% ☐	2

* Weak is a score of 1 point

** Mid-Range is a score of 2 points

*** Strong is a score of 3 points

SUM 11

AVERAGE 2.2

Boston

Worksheet E, Continued

B. Calculation of Indicators

1. Overall Net Debt per capita

Overall Net Debt (Calculate: (1) + (2)) $ 1113 (11)

Overall Net Debt as a Percent of Full Market Value of Taxable Property (Calculate: [(11)/(3)] x 100) NA %(12) *

2. Property Tax Revenues as a Percent of Full Market Value of Taxable Property

Property Tax Revenues as a Percent of Full Market Value of Taxable Property (Calculate: [(10)/(3)] x 100) NA ,(13)

Attachment B
Chelsea MA—Assessment of Substantial Impacts

Introduction

The MWRA projects that the average household in the MWRA service area will pay $463 for wastewater service in fiscal year (FY) 2010, which begins in calendar year (CY) 2009. In the same year the projected cost for both water and wastewater service for the average household in the MWRA service area will be $783. These estimates are based on average household consumption of 61,000 gallons per year (based on actual water consumption as reported to the Massachusetts Department of Environmental Protection). These estimates are based on average household consumption of 61,000 gallons per year (based on actual water consumption as reported to the Massachusetts Department of Environmental Protection). When costs are projected based on the AWWA standard of 90,000 gallons per year, the average household would pay$684 for sewer service and $472 for water service. Combined water and wastewater service costs would be $1,155.

In CY 2009, the MWRA projects that the average household in Chelsea will pay $467 for wastewater service alone, and $630 for water and wastewater service combined, at a usage rate of 61,000 gallons per year. These costs climb to $725 and $965, respectively, at usage of 90,000 gallons per year.

Preliminary Municipal Screener

The purpose of the Preliminary Municipal Screener is to assess whether there is a potential for impacts of proposed pollution control projects to be substantial. The municipal screener determines the average cost of proposed pollution control measures as a percentage of median household income (MHI).

In Chelsea, MHI in 1999 (2000 census) was $30,161. This can be escalated to FY 2001 through use of the consumer price index for the Boston Metropolitan Area, and then estimated to the planning period year of 2009 by escalating the value by 2.5 percent per year. These calculations result in an estimate of CY 2009 MHI of $40,027 for the city of Chelsea.

The projected average cost of wastewater service per household ($467) as a percentage of MHI in CY 2009 ($40,027) is therefore 1.2 percent based on usage of 61,000 gallons per year. The projected CY 2009 combined cost of water and wastewater service ($630) would be 1.6 percent of MHI. At the increased usage of 90,000 gallons per year, wastewater costs as a percentage of MHI climb to 1.8 percent, and combined water and wastewater costs climb to 2.4 percent of MHI.

Secondary Test

The purpose of the secondary test is to assess the financial health of a community. Six different financial indicators are used. These include Bond Rating, Overall Net Debt as a Percent of Full Market Value of Taxable Property, Unemployment, Median Household Income, Property Tax Revenues as Percent of Full Market Value (FMV) of Taxable Property, and Property Tax Collection Rate. Of these six factors, two have had to be modified in Massachusetts because of Proposition 2 ½ which limits the amount of property tax revenue a community can assess and

collect. For this reason, the factor evaluating overall net dept as a percent of FMV of taxable property has been changed to overall net debt per capita, and the factor evaluating property tax revenues as a percent of FMV has been eliminated. Thus, only five factors have been used to assess the financial health of the city of Chelsea (see attached worksheets E and F from the EPA Guidance).

Each of the five factors is assigned a score from 1-3, with 1 representing economic weakness and 3 representing economic strength. The scores are then averaged to provide an overall score. For the city of Chelsea, the five factors and the ratings are as follows.

Bond Rating: Chelsea's bond rating in FY 2002 was Baa1 (Moody's). A Baa1 rating is a component of the Baa class and is considered mid-range and is assigned two points.

Debt Per Capita: Chelsea's debt per capita in FY 2002 is approximately $5,358. Per capita debt of greater than $3,000 is considered to represent a weak financial condition and is assigned one point.

Unemployment: Chelsea's unemployment rate in FY 2002 was 7.4, above the national average at the same time period of 5.8. An unemployment rate above the national average is considered to represent a weak condition and is assigned one point.

Median Household Income: Chelsea's MHI in the 2000 census was $30,161 compared to the state median of $50,502. Thus the indicator would represent a weak condition and is assigned one point.

Property Tax Collection Rate: Chelsea's property tax collection rate in FY 2002 was approximately 97%. This is considered a mid-range condition and is assigned two points.

Total Secondary Score: Chelsea's total score would be 7, with an average score of 1.4, indicating a weak financial condition.

Evaluating Substantial Impact

EPA's Economic Guidance for Water Quality Standards provides a matrix, shown below, which integrates the results of the preliminary municipal screener and the secondary score. Based on a municipal screener of 1.2 (wastewater costs alone) or 1.6 (wastewater and water costs combined) and a secondary score of 1.4, at average usage of 61,000 gallons per year per household, Chelsea would fall in the middle column of the top row, indicating a substantial impact. Chelsea moves to the top cell in the right column when rates are projected at the higher usage of 90,000 gallons per year. Combined water and wastewater costs push the impact to residential rate payers above 2.0 percent.

Thus Chelsea would be expected to incur a substantial impact due to the implementation of the recommended plan for CSO control.

Secondary Score	Municipal Preliminary Screener		
	Less than 1.0 Percent	Between 1.0 and 2.0 Percent	Greater than 2.0 Percent
Less than 1.5	?	X	X
Between 1.5 and 2.5	√	?	X
Greater than 2.5	√	√	?

Further Information to Support Determination of Widespread Impact

Labor Force and Unemployment. As reported by the Massachusetts Division of Employment and Training, the 2002 annual unemployment rate for Chelsea (8.1 percent) was higher than the rate for Massachusetts as a whole (5.3 percent).

Housing. The city of Chelsea has the sixth highest percentage of subsidized housing units in the state with 17 percent of the housing stock classified as subsidized. According to the Department of Housing and Community Development, Chelsea had a total of 910 public housing units in the year 1999. In 1999, the city had an additional 161 mobile (tenant-based) Massachusetts Rental Vouchers and 311 Federal Section 8 vouchers.

Education. Only 59.5 percent of the population of Chelsea over the age of 25 are high school graduates, including high school equivalency. In the state of Massachusetts, 84.8 percent of residents over age 25 have attained high school graduation or equivalency. Ten percent of Chelsea residents over age 25 have a bachelor degree or higher, compared to 33.2 percent in Massachusetts as a whole. Only three percent of the population of Chelsea over age 25 has obtained a graduate or professional degree, whereas in Massachusetts state, 13.7 of residents over age 25 have earned a graduate or professional degree.

Income. The median household income for Chelsea as reported in the 2000 Census was $30,161, only 60 percent of the state median of $50,502. The median family income of $32,130 in Chelsea is only slightly more than half the state median family income of $61,644. Federal guidelines define the poverty level for 2000 for a family of four as approximately $17,050 per year. According to the 2000 Census, 20.6 percent of Chelsea families live below the poverty line. In contrast, 6.7 percent of Massachusetts families live below the poverty line.

Health Characteristics. Chelsea's teen birth rate is nearly double the rate for Massachusetts state, with 13.6 percent of pregnancies in women under 20 years of age, and 5.4 percent of pregnancies in women less than 18 years old. The state average teen birth rates are less than half, with 6.2 percent in women under 20 years old and 2.1 percent in women under 18 years of age. The percentage of women receiving adequate prenatal care is lower in Chelsea (78.1%) than Massachusetts as a whole (85.2%).

State Aid. Based on estimates from the Department of Revenue, Cambridge's state aid for FY 2003 is 0.8 percent less than state aid received for FY 2002 ($61.6 million and $62.1 million, respectively).

In summary, it is clear from the analysis presented herein that the city is already under severe economic stress, and implementation of the CSO control projects would result in substantial and widespread social and economic impacts on the residents of Chelsea.

Worksheet E

Chelsea

Data Used in the Secondary Test

Please list the following values used in determining the Secondary Score. Potential sources of the data are indicated.

FY02 unless otherwise noted

A. Data Collection

Data	Potential Source	Value	
Direct Net Debt	Community Financial Statements Town, County or State Assessor's Office	$ 109,974,051	(1)
Overlapping Debt	Community Financial Statements Town, County or State Assesor's Office	$ 78,000,000	(2)
Market Value of Property	Community Financial Statements Town, County or State Assessor's Office	$ 1,188,181,620	(3)
Bond Rating	Standard and Poors or Moody's	Baa (Moody's)	(4)
Community Unemployment Rate	2000 Census of Population Regional Data Centers	7.4	%(5)
National Unemployment Rate	Bureau of Labor Statistics (202) 606-6392	5.8	(6)
Community Median Household Income	2000 Census of Population	$ 30161	*
State Median Household Income	2000 Census of Population	$ 50502	(8)
Property Tax Collection Rate	Community Financial Statements Town, County or State Assessor's Office	97%	(9)
Property Tax Revenues	Community Financial Statements Town, County or State Assessor's Office	$ 22,528,000	(10)

2000 population - 35,080

Worksheet E, Continued Chelsea

B. Calculation of Indicators

1. Overall Net Debt per capita

Overall Net Debt (Calculate: (1) + (2)) $ 5358 (11)

Overall Net Debt as a Percent of Full Market Value of Taxable Property (Calculate: [(11)/(3)] x 100) NA %(12) *

2. Property Tax Revenues as a Percent of Full Market Value of Taxable Property

Property Tax Revenues as a Percent of Full Market Value of Taxable Property (Calculate: [(10)/(3)] x 100) NA ,(13)

Wo[illegible]eet F

Calculating The Secondary Score

Chelsea

Please check the appropriate box in each row, and record the corresponding score in the final column. Then, sum the scores and compute the average. Remember, if one of the debt or socioeconomic indicators is not available, average the two financial management indicators and use this averaged value as a single indicator with the remaining indicators.

	Secondary Indicators			Score
Indicator	Weak*	Mid-Range**	Strong***	
Bond Rating Worksheet E, (4)	Below BBB (S&P) Below Baa (Moody's) ☐	BBB (S&P) Baa (Moody's) XX	Above BBB (S&P) or Baa (Moody's) ☐	2
Overall Net Debt Per Capita	Above $3,000 XX	$1,000-$3,000 ☐	Below $1,000 ☐	1
Unemployment Worksheet E, (5)& (6)	Above National Average XX	National Average ☐	Below National Average ☐	1
Median Household Income Worksheet E, (7) & (8)	Below State Median XX	State Median ☐	Above State Median ☐	1
Property Tax Revenues as a Percent of Full Market Value of Taxable Property Worksheet E, (13)	Above 4% ☐	2%-4% ☐	Below 2% ☐	N/A
Property Tax Collection Rate Worksheet E, (9)	< 94% ☐	94% - 98% XX	> 98% ☐	2

* Weak is a score of 1 point

** Mid-Range is a score of 2 points

*** Strong is a score of 3 points

SUM: 7

AVERAGE: 1.4

Attachment C
Cambridge MA—Assessment of Substantial Impacts

Introduction

The MWRA projects that the average household in the MWRA service area will pay $463 for wastewater service in fiscal year (FY) 2010, which begins in calendar year (CY) 2009. In the same year, the projected cost for wastewater and water service combined is estimated to be $783 per household. These estimates are based on average household consumption of 61,000 gallons per year (based on actual water consumption as reported to the Massachusetts Department of Environmental Protection). When costs are projected based on the AWWA standard of 90,000 gallons per year, the average household would pay$684 for sewer service and $472 for water service. Combined water and wastewater service costs would be $1,155.

The estimated household costs for both water and wastewater service in Cambridge are slightly lower than the average MWRA rate for the service area. Projected wastewater costs alone in the city of Cambridge in CY 2009 are expected to be $484 per household, and combined water and wastewater costs are expected to be $676, at a usage rate of 61,000 gallons per year. These costs climb to $750 and $1,033, respectively, at usage of 90,000 gallons per year.

Preliminary Municipal Screener

The purpose of the Preliminary Municipal Screener is to assess whether there is a potential for impacts of proposed pollution control projects to be substantial. The municipal screener determines the average cost of proposed pollution control measures as a percentage of median household income (MHI).

In Cambridge, MHI in 1999 (2000 census) was $47,979. This can be escalated to FY 2001 through use of the consumer price index for the Boston Metropolitan Area, and then escalated at 2.5 percent per year through CY 2009. These calculations result in an estimate of CY 2009 MHI of $63,674 for the city of Cambridge.

The projected average cost of wastewater service per household ($484) as a percentage of MHI in CY 2009 ($63,674) is therefore 0.008, or approximately 1.0 percent, based on usage of 61,000 gallons per year. The projected CY 2009 combined cost of water and wastewater service ($676) would be 1.1 percent of MHI. At the increased usage of 90,000 gallons per year, wastewater costs as a percentage of MHI climb to 1.2 percent, and combined water and wastewater costs climb to 1.6 percent of MHI.

Secondary Test

The purpose of the secondary test is to assess the financial health of a community. Six different financial indicators are used. These include Bond Rating, Overall Net Debt as a Percent of Full Market Value of Taxable Property, Unemployment, Median Household Income, Property Tax Revenues as Percent of Full Market Value (FMV) of Taxable Property, and Property Tax Collection Rate. Of these six factors, two have had to be modified in Massachusetts because of Proposition 2 ½ which limits the amount of property tax revenue a community can assess and collect. For this reason, the factor evaluating overall net dept as a percent of FMV of taxable

property has been changed to overall net debt per capita, and the factor evaluating property tax revenues as a percent of FMV has been eliminated. Thus, only five factors have been used to assess the financial health of the city of Cambridge (see attached worksheets E and F from the EPA Guidance).

Each of the five factors is assigned a score from 1-3, with 1 representing economic weakness and 3 representing economic strength. The scores are then averaged to provide an overall score. For the city of Cambridge, the five factors and the ratings are as follows.

Bond Rating: Cambridge's bond rating in FY 2002 was Aaa (Moody's). An Aaa rating is considered a strong indicator and is assigned three points.

Debt Per Capita: Cambridge's debt per capita in FY 2002 was approximately $3,633. Per capita debt of greater than $3,000 is considered weak and is assigned one point.

Unemployment: Cambridge's unemployment rate in FY 2002 was 3.5, below the national average at the same time period of 5.8. An unemployment rate below the national average is considered to represent a strong condition and is assigned three points.

Median Household Income: Cambridge's MHI in the 2000 census was $47,979 compared to the state median of $50,502. Thus, the indicator would represent a weak condition and is assigned one point.

Property Tax Collection Rate: Cambridge's property tax collection rate in FY 2002 was approximately 99.6%. This is considered a strong condition and is assigned three points.

Total Secondary Score: Cambridge's total score would be 11, with an average score of 2.2, indicating financial health in the mid-range category.

Evaluating Substantial Impact

EPA's Economic Guidance for Water Quality Standards provide a matrix, shown below, which integrates the results of the preliminary municipal screener and the secondary score. Based on a municipal screener of approximately 1.0 percent when considering wastewater costs alone, or 1.1 percent when considering both water and wastewater costs, and a secondary score of 2.2, at average usage of 61,000 gallons per year per household, Cambridge would fall in the middle cell of the middle column, indicating the impact is unclear, but could be potentially substantial. These numbers are confirmed at the higher usage rate of 90,000 gallons per year per household.

Secondary Score	Municipal Preliminary Screener		
	Less than 1.0 Percent	Between 1.0 and 2.0 Percent	Greater than 2.0 Percent
Less than 1.5	?	X	X
Between 1.5 and 2.5	√	?	X
Greater than 2.5	√	√	?

Further Information to Support Determination of Widespread Impact

Housing. The city of Cambridge has the seventh highest percentage of subsidized housing units in the state with 15.6 percent of the housing stock classified as subsidized. According to the Department of Housing and Community Development, Cambridge had a total of 2,716 public housing units in the year 1999. In 1999, the city had an additional 219 mobile (tenant-based) Massachusetts Rental Vouchers and 1,763 Federal Section 8 vouchers.

Income. The median household income for Cambridge as reported in the 2000 Census was $47,979, which is 95 percent of the state median of $50,502. The median family income of $59,423 in Cambridge is also below the state median family income of $61,644. Federal guidelines define the poverty level for 2000 for a family of four as approximately $17,050 per year. According to the 2000 Census, 8.7 percent of Cambridge families live below the poverty line. In contrast, 6.7 percent of Massachusetts families live below the poverty line.

Health Characteristics. The percentage of low birth weights (less than 5.5 pounds) in Cambridge is higher than Massachusetts as a whole (12.5 percent and 9.8 percent, respectively). In addition, the percentage of preterm babies (less than 37 weeks gestational age) is more than double the percentage for the state (18.8 percent and 8.9 percent, respectively).

State Aid. Based on estimates from the Department of Revenue, Cambridge's state aid for FY 2003 is 1.6 percent less than state aid received for FY 2002 ($43.2 million and $44.0 million, respectively).

In summary, although EPA's Economic Guidance for Water Quality Standards matrix indicates that substantial impact as a result of the implementation of the recommended plan for CSO control is unclear, the information presented above supports that Cambridge is currently experiencing economic stress. Thus, implementation of the CSO control projects would likely result in substantial and widespread social and economic impacts on the residents of the city.

References for Attachments A, B, and C.

City of Cambridge, 2002. Comprehensive Annual Financial Report.

Massachusetts Department of Housing and Community Development, 2003. Community Profiles for Boston, Cambridge, and Chelsea.

Massachusetts Department of Public Health, 2003. Massachusetts Births 2001. April 2003.

Massachusetts Department of Public Health, 2003. Massachusetts Community Health Information Profile (MassCHIP): Prenatal and Perinatal Trends for Boston, Cambridge, and Chelsea. Available online: http://masschip.state.ma.us/InstantTopics/instant.asp.

Massachusetts Department of Revenue, Division of Local Services, 2003. Fiscal Year 2001-2002 Excess Levy Capacity.

Massachusetts Department of Revenue, Division of Local Services, 2002. Community Comparison Report: At A Glance Reports for Boston, Cambridge, and Chelsea.

Massachusetts Department of Revenue, Division of Local Services, 2001. Fiscal Year 2002 "Cherry Sheet" for Boston, Cambridge, and Chelsea. December, 2001.

Massachusetts Department of Revenue, Division of Local Services, 2002. Fiscal Year 2003 "Cherry Sheet" for Boston, Cambridge, and Chelsea. August, 2002.

Massachusetts Division of Employment and Training, 2003. Labor Force and Unemployment Data. Available online: http://lmi2.detma.org/lmi/lmi_lur_a.asp.

U.S. Department of Commerce, Bureau of the Census, 2000. Census 2000 Summary Files 1 and 3.

Worksheet E

Cambridge

Data Used in the Secondary Test

Please list the following values used in determining the Secondary Score. Potential sources of the data are indicated.

FY02 unless noted otherwise

A. Data Collection

Data	Potential Source	Value	
Direct Net Debt	Community Financial Statements Town, County or State Assessor's Office	$ 212,729,858	(1)
Overlapping Debt	Community Financial Statements Town, County or State Assesor's Office	$ 155,502,604	(2)
Market Value of Property	Community Financial Statements Town, County or State Assessor's Office	$ 16,837,087,126	(3)
Bond Rating	Standard and Poors or Moody's	Aaa (Moody's)	(4)
Community Unemployment Rate	2000 Census of Population Regional Data Centers	3.5	%(5)
National Unemployment Rate	Bureau of Labor Statistics (202) 606-6392	5.8	(6)
Community Median Household Income	2000 Census of Population	$ 47,979	*
State Median Household Income	2000 Census of Population	$ 50,502	(8)
Property Tax Collection Rate	Community Financial Statements Town, County or State Assessor's Office	99.6%	(9)
Property Tax Revenues	Community Financial Statements Town, County or State Assessor's Office	$ 187,444,551	(10)

2000 population - 101,355

Worksheet E, Continued

Cambridge

B. Calculation of Indicators

1. Overall Net Debt per capita

Overall Net Debt (Calculate: (1) + (2))	$ 3,633	(11)
Overall Net Debt as a Percent of Full Market Value of Taxable Property (Calculate: [(11)/(3)] x 100)	NA %	(12) *

2. Property Tax Revenues as a Percent of Full Market Value of Taxable Property

Property Tax Revenues as a Percent of Full Market Value of Taxable Property (Calculate: [(10)/(3)] x 100)	NA	,(13)

Wo' eet F

Calculating The Secondary Score

Cambridge

Please check the appropriate box in each row, and record the corresponding score in the final column. Then, sum the scores and compute the average. Remember, if one of the debt or socioeconomic indicators is not available, average the two financial management indicators and use this averaged value as a single indicator with the remaining indicators.

	Secondary Indicators			Score
Indicator	Weak*	Mid-Range**	Strong***	
Bond Rating Worksheet E, (4)	Below BBB (S&P) Below Baa (Moody's) [ ]	BBB (S&P) Baa (Moody's) [ ]	Above BBB (S&P) or Baa (Moody's) [X]	3
Overall Net Debt Per Capita	Above $3,000 [X]	$1,000-$3,000 [ ]	Below $1,000 [ ]	1
Unemployment Worksheet E, (5)& (6)	Above National Average [ ]	National Average [ ]	Below National Average [X]	3
Median Household Income Worksheet E, (7) & (8)	Below State Median [X]	State Median [ ]	Above State Median [ ]	1
Property Tax Revenues as a Percent of Full Market Value of Taxable Property Worksheet E, (13)	Above 4% [ ]	2%-4% [ ]	Below 2% [ ]	N/A
Property Tax Collection Rate Worksheet E, (9)	< 94% [ ]	94% - 98% [ ]	> 98% [X]	3

* Weak is a score of 1 point

** Mid-Range is a score of 2 points

*** Strong is a score of 3 points

SUM 11

AVERAGE 2.2

ESTIMATED RATES USING 61,000 GALLONS PER YEAR PER HOUSEHOLD

Municipality	2009 Median Household Income[1,2,3]	Number of Households[1]	Weight	Weighted MHI	2009 Estimated Sewer Charge[4]	2009 Estimated Water Charge[4]	Estimated Combined Household Charge[4]	Residential Indicator: Sewer	Residential Indicator: Water	Residential Indicator: Combined	Weighted Sewer Charge	Weighted Water Charge	Weighted Combined Charge	Financial Impact (Sewer Only)	Financial Impact (Combined)
Arlington	$85,392	19,011	2.24%	$1,910	$232.06	$317.40	$549.47	0.27%	0.37%	0.64%	$5.19	$7.10	$12.29	Low	Low
Ashland	90,764	5,720	0.67%	611	655.58	356.44	1,012.02	0.72%	0.39%	1.12%	$4.41	$2.40	$6.81	Low	Mid-Range
Bedford	116,736	4,621	0.54%	635	492.17	401.30	893.47	0.42%	0.34%	0.77%	$2.68	$2.18	$4.86	Low	Low
Belmont	106,561	9,732	1.15%	1,220	702.19	560.76	1,262.94	0.66%	0.53%	1.19%	$8.04	$6.42	$14.46	Low	Mid-Range
Boston	52,592	239,528	28.18%	14,822	397.42	289.87	687.29	0.76%	0.55%	1.31%	$112.01	$81.69	$193.70	Low	Mid-Range
Braintree	82,002	12,600	1.48%	1,216	495.07	300.67	795.74	0.60%	0.37%	0.97%	$7.34	$4.46	$11.80	Low	Low
Brookline	88,533	25,594	3.01%	2,666	475.73	494.66	970.39	0.54%	0.56%	1.10%	$14.33	$14.90	$29.22	Low	Mid-Range
Burlington	99,852	8,289	0.98%	974	252.56	124.76	377.32	0.25%	0.12%	0.38%	$2.46	$1.22	$3.68	Low	Low
Cambridge	63,674	42,615	5.01%	3,193	483.85	343.35	827.20	0.76%	0.54%	1.30%	$24.26	$17.22	$41.48	Low	Mid-Range
Canton	91,916	7,952	0.94%	860	499.71	298.25	797.96	0.54%	0.32%	0.87%	$4.68	$2.79	$7.47	Low	Low
Chelsea	40,027	11,888	1.40%	560	467.61	290.97	758.58	1.17%	0.73%	1.90%	$6.54	$4.07	$10.61	Mid-Range	**Mid-Range**
Dedham	81,882	8,654	1.02%	834	625.41	580.06	1,205.47	0.76%	0.71%	1.47%	$6.37	$5.91	$12.27	Low	Mid-Range
Everett	53,962	15,435	1.82%	980	411.91	189.13	601.05	0.76%	0.35%	1.11%	$7.48	$3.43	$10.92	Low	Mid-Range
Framingham	72,046	26,153	3.08%	2,217	344.61	290.97	635.59	0.48%	0.40%	0.88%	$10.60	$8.95	$19.56	Low	Low
Hingham	110,174	7,189	0.85%	932	672.99	923.55	1,596.54	0.61%	0.84%	1.45%	$5.69	$7.81	$13.50	Low	Mid-Range
Holbrook	72,220	4,076	0.48%	346	371.30	203.68	574.98	0.51%	0.28%	0.80%	$1.78	$0.98	$2.76	Low	Low
Lexington	128,498	11,110	1.31%	1,680	702.77	405.91	1,108.68	0.55%	0.32%	0.86%	$9.19	$5.31	$14.49	Low	Low
Malden	60,588	23,009	2.71%	1,640	370.92	251.21	622.12	0.61%	0.41%	1.03%	$10.04	$6.80	$16.84	Low	Mid-Range
Medford	69,642	22,067	2.60%	1,808	557.08	365.40	922.48	0.80%	0.52%	1.32%	$14.46	$9.49	$23.95	Low	Mid-Range
Melrose	83,357	10,982	1.29%	1,077	502.30	314.25	816.55	0.60%	0.38%	0.98%	$6.49	$4.06	$10.55	Low	Low
Milton	104,822	8,982	1.06%	1,108	767.67	424.82	1,192.49	0.73%	0.41%	1.14%	$8.11	$4.49	$12.60	Low	Mid-Range
Natick	92,573	13,080	1.54%	1,425	709.54	244.18	953.71	0.77%	0.26%	1.03%	$10.92	$3.76	$14.68	Low	Mid-Range
Needham	116,891	10,612	1.25%	1,460	707.21	261.00	968.22	0.61%	0.22%	0.83%	$8.83	$3.26	$12.09	Low	Low
Newton	114,201	31,201	3.67%	4,192	534.52	330.74	865.26	0.47%	0.29%	0.76%	$19.62	$12.14	$31.77	Low	Low
Norwood	77,531	11,623	1.37%	1,060	444.17	288.06	732.23	0.57%	0.37%	0.94%	$6.07	$3.94	$10.01	Low	Low
Quincy	62,535	38,883	4.58%	2,861	449.16	292.43	741.59	0.72%	0.47%	1.19%	$20.55	$13.38	$33.93	Low	Mid-Range
Randolph	73,330	11,313	1.33%	976	371.88	225.51	597.39	0.51%	0.31%	0.81%	$4.95	$3.00	$7.95	Low	Low
Reading	102,266	8,688	1.02%	1,045	597.56	532.48	1,130.05	0.58%	0.52%	1.11%	$6.11	$5.44	$11.55	Low	Mid-Range
Revere	49,192	19,463	2.29%	1,127	439.76	218.23	657.99	0.89%	0.44%	1.34%	$10.07	$5.00	$15.07	Low	Mid-Range
Somerville	61,465	31,555	3.71%	2,282	443.24	356.44	799.69	0.72%	0.58%	1.30%	$16.46	$13.23	$29.69	Low	Mid-Range
Stoneham	75,121	9,050	1.06%	800	701.99	400.09	1,102.08	0.93%	0.53%	1.47%	$7.48	$4.26	$11.74	Low	Mid-Range
Stoughton	76,758	10,254	1.21%	926	798.30	320.70	1,119.00	1.04%	0.42%	1.46%	$9.63	$3.87	$13.50	Mid-Range	Mid-Range
Wakefield	87,745	9,747	1.15%	1,006	680.72	378.27	1,058.99	0.78%	0.43%	1.21%	$7.81	$4.34	$12.14	Low	Mid-Range
Walpole	99,211	8,060	0.95%	941	450.95	380.30	831.25	0.45%	0.38%	0.84%	$4.28	$3.61	$7.88	Low	Low
Waltham	71,677	23,207	2.73%	1,957	404.72	246.89	651.61	0.56%	0.34%	0.91%	$11.05	$6.74	$17.79	Low	Low
Watertown	79,314	14,629	1.72%	1,365	465.29	263.21	728.50	0.59%	0.33%	0.92%	$8.01	$4.53	$12.54	Low	Low
Wellesley	150,874	8,594	1.01%	1,526	527.95	344.08	872.02	0.35%	0.23%	0.58%	$5.34	$3.48	$8.82	Low	Low
Westwood	115,982	5,122	0.60%	699	612.07	580.06	1,192.13	0.53%	0.50%	1.03%	$3.69	$3.50	$7.18	Low	Mid-Range
Weymouth	68,565	22,028	2.59%	1,777	647.07	361.20	1,008.27	0.94%	0.53%	1.47%	$16.77	$9.36	$26.13	Low	Mid-Range
Wilmington	93,763	7,027	0.83%	775	248.31	357.90	606.21	0.26%	0.38%	0.65%	$2.05	$2.96	$5.01	Low	Low
Winchester	124,814	7,715	0.91%	1,133	242.51	242.24	484.74	0.19%	0.19%	0.39%	$2.20	$2.20	$4.40	Low	Low
Winthrop	70,499	7,843	0.92%	651	538.39	370.99	909.38	0.76%	0.53%	1.29%	$4.97	$3.42	$8.39	Low	Mid-Range
Woburn	72,855	14,997	1.76%	1,286	225.94	164.89	390.83	0.31%	0.23%	0.54%	$3.99	$2.91	$6.90	Low	Low
	85,870	849,898	100.00%	72,558							$462.99	$320.00	$782.99		
										System Charges/MHI:	**0.64%**	**0.44%**	**1.08%**	**Low**	**Mid-Range**

1) 1999 (base) median household income and number of households source: U.S. 2000 Census (1999 Data)
2) 1999 median household income inflated by 4.32% in 2000, 4.3% in 2001, and 2.61% in 2002 according to the CPI for the Boston (NE) area as provided by the Bureau of Labor Statistics.
3) Median household income inflated by 2.5% annually for years 2002-2012, the assumed rate of inflation in MWRA planning estimates.
4) Based on MWRA FY04 CEB

FY09 Estimated Household Charge (Sewer)	$428	FY10 Increase (Sewer)	$35
FY09 Estimated Household Charge (Water)	$300	FY10 Increase (Water)	$20
FY09 Estimated Household Charge (Combined)	$728	FY10 Increase (Combined)	$55
FY10 Estimated Household Charge (Sewer)	$463	FY10 Increase (Sewer)	8.18%
FY10 Estimated Household Charge (Water)	$320	FY10 Increase (Water)	6.67%
FY10 Estimated Household Charge (Combined)	$783	FY10 Increase (Combined)	7.55%

ESTIMATED RATES USING 90,000 GALLONS PER YEAR PER HOUSEHOLD

Municipality *	2009 Median Household Income[1,2,3]	Number of Households[1]	Weight	Weighted MHI	2009 Estimated Sewer Charge[4]	2009 Estimated Water Charge[4]	Estimated Combined Household Charge[4]	Residential Indicator: Sewer	Residential Indicator: Water	Residential Indicator: Combined	Weighted Sewer Charge	Weighted Water Charge	Weighted Combined Charge	Financial Impact (Sewer Only)	Financial Impact (Combined)
Arlington	$85,392	19,011	2.24%	$1,910	$359.74	$482.18	$841.92	0.42%	0.56%	0.99%	$8.05	$10.79	$18.83	Low	Low
Ashland	90,764	5,720	0.67%	611	1,016.26	541.49	1,557.74	1.12%	0.60%	1.72%	$6.84	$3.64	$10.48	Mid-Range	Mid-Range
Bedford	116,736	4,621	0.54%	635	762.94	609.63	1,372.58	0.65%	0.52%	1.18%	$4.15	$3.31	$7.46	Low	Mid-Range
Belmont	106,561	9,732	1.15%	1,220	1,088.50	851.87	1,940.37	1.02%	0.80%	1.82%	$12.46	$9.75	$22.22	Mid-Range	Mid-Range
Boston	52,592	239,528	28.18%	14,822	616.06	440.36	1,056.42	1.17%	0.84%	2.01%	$173.63	$124.11	$297.73	Mid-Range	High
Braintree	82,002	12,600	1.48%	1,216	767.44	456.77	1,224.20	0.94%	0.56%	1.49%	$11.38	$6.77	$18.15	Low	Mid-Range
Brookline	88,533	25,594	3.01%	2,666	737.46	751.45	1,488.91	0.83%	0.85%	1.68%	$22.21	$22.63	$44.84	Low	Mid-Range
Burlington	99,852	8,289	0.98%	974	391.51	189.52	581.03	0.39%	0.19%	0.58%	$3.82	$1.85	$5.67	Low	Low
Cambridge	63,674	42,615	5.01%	3,193	750.05	521.60	1,271.65	1.18%	0.82%	2.00%	$37.61	$26.15	$63.76	Mid-Range	Mid-Range
Canton	91,916	7,952	0.94%	860	774.63	453.08	1,227.72	0.84%	0.49%	1.34%	$7.25	$4.24	$11.49	Low	Mid-Range
Chelsea	40,027	11,888	1.40%	560	724.87	442.03	1,166.90	1.81%	1.10%	2.92%	$10.14	$6.18	$16.32	Mid-Range	**High**
Dedham	81,882	8,654	1.02%	834	969.49	881.19	1,850.68	1.18%	1.08%	2.26%	$9.87	$8.97	$18.84	Mid-Range	High
Everett	53,962	15,435	1.82%	980	638.53	287.32	925.85	1.18%	0.53%	1.72%	$11.60	$5.22	$16.81	Mid-Range	Mid-Range
Framingham	72,046	26,153	3.08%	2,217	534.21	442.03	976.24	0.74%	0.61%	1.36%	$16.44	$13.60	$30.04	Low	Mid-Range
Hingham	110,174	7,189	0.85%	932	1,043.24	1,403.01	2,446.24	0.95%	1.27%	2.22%	$8.82	$11.87	$20.69	Low	High
Holbrook	72,220	4,076	0.48%	346	575.58	309.42	885.00	0.80%	0.43%	1.23%	$2.76	$1.48	$4.24	Low	Mid-Range
Lexington	128,498	11,110	1.31%	1,680	1,089.40	616.63	1,706.04	0.85%	0.48%	1.33%	$14.24	$8.06	$22.30	Low	Mid-Range
Malden	60,588	23,009	2.71%	1,640	574.98	381.62	956.60	0.95%	0.63%	1.58%	$15.57	$10.33	$25.90	Low	Mid-Range
Medford	69,642	22,067	2.60%	1,808	863.56	555.10	1,418.66	1.24%	0.80%	2.04%	$22.42	$14.41	$36.83	Mid-Range	High
Melrose	83,357	10,982	1.29%	1,077	778.65	477.39	1,256.04	0.93%	0.57%	1.51%	$10.06	$6.17	$16.23	Low	Mid-Range
Milton	104,822	8,982	1.06%	1,108	1,190.01	645.37	1,835.38	1.14%	0.62%	1.75%	$12.58	$6.82	$19.40	Mid-Range	Mid-Range
Natick	92,573	13,080	1.54%	1,425	1,099.90	370.94	1,470.83	1.19%	0.40%	1.59%	$16.93	$5.71	$22.64	Mid-Range	Mid-Range
Needham	116,891	10,612	1.25%	1,460	1,096.30	396.50	1,492.80	0.94%	0.34%	1.28%	$13.69	$4.95	$18.64	Low	Mid-Range
Newton	114,201	31,201	3.67%	4,192	828.59	502.44	1,331.04	0.73%	0.44%	1.17%	$30.42	$18.45	$48.86	Low	Mid-Range
Norwood	77,531	11,623	1.37%	1,060	688.54	437.61	1,126.15	0.89%	0.56%	1.45%	$9.42	$5.98	$15.40	Low	Mid-Range
Quincy	62,535	38,883	4.58%	2,861	696.27	444.24	1,140.51	1.11%	0.71%	1.82%	$31.85	$20.32	$52.18	Mid-Range	Mid-Range
Randolph	73,330	11,313	1.33%	976	576.48	342.57	919.05	0.79%	0.47%	1.25%	$7.67	$4.56	$12.23	Low	Mid-Range
Reading	102,266	8,688	1.02%	1,045	926.32	808.92	1,735.24	0.91%	0.79%	1.70%	$9.47	$8.27	$17.74	Low	Mid-Range
Revere	49,192	19,463	2.29%	1,127	681.70	331.52	1,013.22	1.39%	0.67%	2.06%	$15.61	$7.59	$23.20	Mid-Range	High
Somerville	61,465	31,555	3.71%	2,282	687.10	541.49	1,228.59	1.12%	0.88%	2.00%	$25.51	$20.10	$45.61	Mid-Range	Mid-Range
Stoneham	75,121	9,050	1.06%	800	1,088.20	607.79	1,696.00	1.45%	0.81%	2.26%	$11.59	$6.47	$18.06	Mid-Range	High
Stoughton	76,758	10,254	1.21%	926	1,237.49	487.19	1,724.69	1.61%	0.63%	2.25%	$14.93	$5.88	$20.81	Mid-Range	High
Wakefield	87,745	9,747	1.15%	1,006	1,055.23	574.64	1,629.87	1.20%	0.65%	1.86%	$12.10	$6.59	$18.69	Mid-Range	Mid-Range
Walpole	99,211	8,060	0.95%	941	699.04	577.73	1,276.78	0.70%	0.58%	1.29%	$6.63	$5.48	$12.11	Low	Mid-Range
Waltham	71,677	23,207	2.73%	1,957	627.38	375.06	1,002.44	0.88%	0.52%	1.40%	$17.13	$10.24	$27.37	Low	Mid-Range
Watertown	79,314	14,629	1.72%	1,365	721.27	399.85	1,121.13	0.91%	0.50%	1.41%	$12.42	$6.88	$19.30	Low	Mid-Range
Wellesley	150,874	8,594	1.01%	1,526	818.40	522.70	1,341.10	0.54%	0.35%	0.89%	$8.28	$5.29	$13.56	Low	Low
Westwood	115,982	5,122	0.60%	699	948.81	881.19	1,830.00	0.82%	0.76%	1.58%	$5.72	$5.31	$11.03	Low	Mid-Range
Weymouth	68,565	22,028	2.59%	1,777	1,003.07	548.71	1,551.77	1.46%	0.80%	2.26%	$26.00	$14.22	$40.22	Mid-Range	High
Wilmington	93,763	7,027	0.83%	775	384.92	543.70	928.62	0.41%	0.58%	0.99%	$3.18	$4.50	$7.68	Low	Low
Winchester	124,814	7,715	0.91%	1,133	375.93	367.99	743.92	0.30%	0.29%	0.60%	$3.41	$3.34	$6.75	Low	Low
Winthrop	70,499	7,843	0.92%	651	834.59	563.59	1,398.18	1.18%	0.80%	1.98%	$7.70	$5.20	$12.90	Mid-Range	Mid-Range
Woburn	72,855	14,997	1.76%	1,286	333.94	250.48	584.42	0.46%	0.34%	0.80%	$5.89	$4.42	$10.31	Low	Low
	85,870	849,898	100.00%	72,558							$717.43	$486.13	$1,203.55		
										System Charges/MHI:	**0.99%**	**0.67%**	**1.66%**	**Low**	**Mid-Range**

1) 1999 (base) median household income and number of households source: U.S. 2000 Census (1999 Data)
2) 1999 median household income inflated by 4.32% in 2000, 4.3% in 2001, and 2.61% in 2002 according to the CPI for the Boston (NE) area as provided by the Bureau of Labor Statistics.
3) Median household income inflated by 2.5% annually for years 2002-2012, the assumed rate of inflation in MWRA planning estimates.
4) Based on MWRA FY04 CEB

FY09 Estimated Household Charge (Sewer)	$631	FY10 Increase (Sewer)	$53
FY09 Estimated Household Charge (Water)	$442	FY10 Increase (Water)	$30
FY09 Estimated Household Charge (Combined)	$1,073	FY10 Increase (Combined)	$82
FY10 Estimated Household Charge (Sewer)	$684	FY10 Increase (Sewer)	8.32%
FY10 Estimated Household Charge (Water)	$472	FY10 Increase (Water)	6.67%
FY10 Estimated Household Charge (Combined)	$1,155	FY10 Increase (Combined)	7.64%